

CD12153

~~RESTRICTED~~

A12/CD/SA96

CD/SA 96

Renewed April 1985

Declassified
f.c.Home Office
Scientific Advisers' BranchThe Decontamination of Residential AreasDr. J. McAulayEffect of Type of Fall-Out

24. The type of fall-out will affect the effort needed to decontaminate access routes in a residential area. The fall-out may be typical of:

(a) a landburst in which the radioactivity is firmly fixed in the fall-out particles and there is no significant transfer of activity to the surface on which the fall-out is deposited even if the deposit is wetted by rain-fall or is hosed or flushed away from the surface.

(b) an offshore and relatively deepwater burst in which large quantities of water and mud are lifted into the cloud so that the fall-out consists primarily of water droplets containing the radioactive fission products (or induced activity) in solution in colloidal suspension which can be transferred to the surface and be retained so tenaciously that the cost and effort of decontamination may be prohibitive.

25. Liquid droplet or "ionic" fall-out from an offshore waterburst would be much more localised and the radioactivity more intense than that from a landburst, leaving a much smaller fringe area in which decontamination might be of value compared with other remedial measures. It is the considered opinion of the Scientific Advisers' Branch that bursts of megaton weapons on British rivers such as the Clyde or the Thames would not raise enough water to produce fall-out differing significantly from that caused by a landburst and that water droplet fall-out with transferable activity would be infrequent compared with the landburst type of fall-out.

26. In view of the above considerations, the process of decontaminating a typical residential area will be primarily one of mechanical removal of the fall-out particles from the surfaces on which they have been deposited. They may be sucked or swept up into a container and removed to a safe dumping ground or they may be swept into the gutter and washed down into street drains or sumps. On some surfaces it may prove more effective to remove the bulk of the fall-out by dry sweeping or suction methods followed by flushing or fire hosing the surface to remove the remainder of the fall-out.

Surface Loading of Fall-Out Simulant in Area Decontamination Trials

30. Most of the trials with megaton weapons have taken place on coral islands and there is little reliable information on the relationship between the surface deposit of fall-out and the associated reference dose-rate contours, and none at all for megaton landbursts on clay or silicate soil. In one Pacific test the surface fall-out loadings at 8 miles and 60 miles downwind of ground zero of a 5 M.T. burst were estimated respectively at 4.5 and 0.06 gms. per square foot, but no systematic data are available. Source: WT-1317

(Redwing-Tewa ships YFNB29 and LST611, 1 hr references: 200 and 6 R/hr)

31. In the large scale decontamination trials at Camp Stoneman in California in September, 1956, carriers impregnated with La 140 were used at a surface loading of 25 mgm. per square foot per r.p.h. at H + 1 hours, to simulate fall-out at 1000 to 10,000 r.p.h. at H + 1. It is probably easier to remove fall-out mechanically at the higher surface loadings and it is felt that the above figure is grossly excessive.

RESTRICTED

Appendix A (I)

Data extracted from Radiological Recovery of Fixed Military Installations

(Report TM 3-225, rev. Apr. 1958.) F.M.I. Sheet I

Performance of Common reclamation methods for paved areas and buildings

Surface of building or paved area	Standard dose-rate at 1 hour after burst	Residual Numbers for decontamination methods (1)		
		Firehosing or street flushing	Firehosing plus scrubbing	Hot liquid (2) cleaning
Asphaltic Concrete	300	0.07	0.05	0.02
	1000	0.03	0.02	0.01
	3000	0.01	0.008	0.004
Portland Cement Concrete	300	0.04	0.03	0.02
	1000	0.02	0.02	0.008
	3000	0.008	0.006	0.003
Tar and gravel roof	300	0.03	0.03	0.01
	1000	0.02	0.02	0.009
	3000	0.01	0.01	0.004
Composition roofing	300	0.04	0.04	0.02
	1000	0.03	0.02	0.01
	3000	0.01	0.01	0.005
Wood shingles (tiles)	300	0.17	0.13	0.06
	1000	0.10	0.08	0.04
	3000	0.04	0.03	0.01
Galvanised steel, corrugated	300	0.05	0.04	0.02
	1000	0.02	0.01	0.006
	3000	0.006	0.005	0.002
Smooth painted surface	300	0.04	0.03	0.01
	1000	0.01	0.008	0.004
	3000	0.004	0.003	0.001

1. In this report the Residual Number is the fractional dose reduction in the centre of the area after the decontamination of the area plus a surrounding buffer zone of 600 feet width of paved or 200 feet of unpaved. Hence the Residual Number also represents the fraction of the radioactive contamination remaining on the surface.

2. Wet steam 105 psig 320°F (1500 lb/hr) and 1000 gal /hour water at 20 psig.

RESTRICTED

Appendix A(I)

F.M.I. Sheet 2 (Report TM 3-225, rev. Apr. 1958.)

Notes on procedure and rates of operation

Paved areas and structures

1. Firehosing

The data relate to the clean up of a large area, the fall-out being pushed into a drainage channel at the far edges. The data on rates of operation are much less than would be the case for typical British streets with gutters and drains.

Equipment: Hydrant, booster pump, 2½ inch hose, Y branch feeding two 1½ inch hoses each delivering 100 gallons per minute at 80 p.s.i.g.

Operators: Four men per 1½ inch hose.

Rate: Areas 7,500 sq. ft. per hour per nozzle.

Structures 2,000 sq. ft. per hour per nozzle.

2. Motorised flushing (for large areas only)

Equipment: Flusher delivering 800 gallons per minute at 90 p.s.i.g.

Operators: Two men.

Rate: 35,000 sq. ft. per hour.

3. Hot liquid cleaning

Equipment: Injector Unit, lance and nozzle, steam (1500 lb/hour unit at 105 p.s.i.g. and 320°F): Water (1000 gallons per hour at 20 p.s.i.g.) and Detergent.

Operators: Three men per lance.

Rate: Roofs 2500 sq. ft./hour

Walls 2000 sq. ft./hour.

RESTRICTED

Appendix A(1)

(Report TM 3-225, rev. Apr. 1958.) F.M.I. Sheet 3

Reclamation characteristics of various surfaces

Surface	Reclamation Characteristics
Composition shingles Prepared roll roofing Tar Paper	Similar to composition roofing
Corrugated sheet metal Steel Transite Glazed brick or tile Tin Copper	Similar to galvanised steel, corrugated
Unpainted wood Wood piles, piers and posts Gypsum or fibreboard Unglazed tile or brick	Similar to wood shingles (i.e. wooden tiles)
Dense brick Cinder or concrete block Adobe brick Semi-glazed roof tile Stone	Similar to Portland Cement, concrete
Slate Asbestos shingles or siding Concrete piles, piers or posts Stucco	Similar to Portland Cement, concrete

RESTRICTED

Appendix A(i)

F. M. I. Sheet 4 (Report TM 3-225, rev. Apr. 1958.)

Performance of Common reclamation methods for unpaved land areas

Method	Residual Number (1) for single pass
Ploughing (8 to 10 inches depth)	0.15
Motor Grader scraping (2) (2 to 4 inches cut)	0.07
Motorised scraping (3) (2 to 6 inches cut)	0.15
Filling (to 6 inches depth)	0.15
Motorised scraping plus either ploughing or filling	0.02

- (1) See note Sheet 1.
- (2) Earth pushed by slanting blade into windrows which are removed from the site.
- (3) Earth lifted into a bucket and dumped off site - higher R. N. due largely to spillage.

RESTRICTED

Appendix A(i)

F.M.I. Sheet 5

(Report TM 3-225, rev. Apr. 1958.)

Unpaved Land

1. Ploughing

Three share plough drawn by 125 HP tractor

Rate 35,000 sq. ft. /hour

One operator per gang of ploughs.

2. Motor grader scraping (without time for removal of windrows)

Motor grader with 10 ft. blade.

Rate along a 16 ft. wide roadway one pass on each half of road.

4,000 linear ft. /hour or

64,000 square ft. /hour.

3. Motorised scraper and bulldozer

The scraper takes soil into a bucket and the rate depends on the distance to the dumping ground and on the roughness of the ground.

4. Filling to a depth of 6 inches

Motorised scraper and bulldozer or mechanical shovel and truck.

Rate 3,000 to 10,000 sq. ft. depending on length of haul and nature of soil.

RESTRICTED

Appendix A(i)

F.M.I. Sheet 6 (Report TM 3-225, rev. Apr. 1958.)

LOGISTICS of Decontamination

Method	Equipment Required per 100,000 sq. ft. (1)	Manpower requirements per unit of equipment
Firehosing Areas	0.28 hoses	4 men
Firehosing structures	1.04 hoses	2 men
Motorised street flusher	0.06 flushers	2 men
Firehosing and hand scrubbing on paved areas	0.42 hoses 0.84 brushes detergents	4 men per hose 2 men for scrubbing
Firehosing and scrubbing on structures	1.04 hoses 2.08 brushes 2.08 shovels detergents	4 men per hose 2 men for scrubbing
Hot liquid cleaning of roofs	0.84 lances	4 men
Ploughing	0.06 tractor with plough	1 man
Motor grader scraping	0.033 motor graders	1 man
Motorised scraping	0.42 scrapers	1 man
Filling	0.42 scrapers	1 man
Bulldozing	0.25 dozers	1 man

(1) Based on 48 hours operation of equipment: numbers are also based on 100% efficiency and do not allow time for setup or rest periods. These factors may reduce the efficiency by 15 to 25%.

RESTRICTED

Appendix A(11)

S. R. I. Sheet 1

Performance Value of Decontamination Measures

(Assuming crew exposure factor of 0.5 i.e. P.F. = 2)

(Data in U. S. gals. = 0.83 British gals.)

Decontamination Measure	Supply needs (per 1000 sq.ft.)	Rate of Coverage sq.ft./man-hr.	Fraction of Radiation Removed	Performance Value (see script)
<u>Roofs</u>				
Firehosing	0.4 gal gas 200 water	1,000	0.9	1,800
Firehosing and scrubbing	0.7 gal gas 1500 water	300	0.93	560
Firehosing and detergent scrubbing	same plus 2 lb detergent.	300	0.97	580
Vacuum cleaning	Electricity	-	0.80	-
<u>Paved Areas</u>				
Firehosing	0.15 gal gas 700 water	2,000	0.96	3,800
Firehosing and scrub	0.2 " " 700 water	900	0.97	1,700
Firehosing and detergent scrub	same plus 2 lb detergent	900	0.98	1,800
Motorised flushing	0.3 gal gas 500 water	15,000	0.98	73,000
Motorised sweeping	0.1 gal gas	25,000	0.90	110,000
<u>Unpaved Areas</u>				
Power scraping or bull-dozing	0.5 gal gas	5,000	0.85	21,000
Motor grading	0.2 gal gas	25,000	0.85	110,000
Gang ploughing	0.2 gal gas	20,000	0.85	85,000
Spading (hand)		50	0.85	85
<u>Obstructions (trees, fences etc.)</u>				
Firehosing	0.4 gal gas 2000 water	1,000	0.8	1,600
Firehosing and scrubbing	0.7 gal gas 2500 water	300	0.9	540
<u>Outside Walls</u>				
Firehosing	0.3 gal gas 1300 water	1,500	0.97	2,900
Firehosing and scrub	0.4 gal gas 900 water	500	0.98	980
Firehosing and detergent scrub	same plus 4 lb detergent	500	0.99	990
Vacuum cleaning	Electricity	-	0.97	-

RESTRICTED-

SYSTEMS ANALYSIS OF RADIOLOGICAL DEFENSE. Kendall D. Moll. Nov. 1958. 124p. (NP-7241) *Stanford Res. Inst.*

Appendix A(ii)

S.R.I. Sheet 2

Distribution of surface area types in a typical American City and their radiation contributions inside shelters

Type of Surface	Shelter in			
	Dwelling houses PF = 2		Commercial Areas Large buildings PF = 10	
	Surface Area sq. ft. per capita	Fraction of the total external radiation penetrating into the shelter from the specified surfaces	Surface Area sq. ft. per capita	Fraction of the total external radiation penetrating into the shelter from the specified surfaces
Roofs	300	0.15	150	0.060
Streets	350	0.06	150	0.005
Other paved areas	300	0.10	150	0.010
Unpaved areas	1,000	0.15	300	0.014
Obstructions (fences, trees, etc.)	400	0.02	100	0.001
Outside Walls	400	0.02	200	0.010
Total exposure as fraction of external		0.50		0.100

RESTRICTED

SYSTEMS ANALYSIS OF RADIOLOGICAL DEFENSE. Kendall D. Moll. Nov. 1958. 124p. (NP-7241) *Stanford Res. Inst.*

Appendix A(11)

S.R.I. Sheet 3

Decontamination Values for dwelling houses (residential areas) and large buildings (commercial areas). Crew exposure factor 0.5 (i.e. P.F.= 2)

Decontamination Measure	Decontamination Value		Hours work per capita to decontaminate		Fraction of radiation removed from the surface	Supply needs per capita to decontaminate all City areas (U.S. gals = 0.85 British gals.)
	Houses (residential)	Large Buildings (commercial)	Houses (residential)	Large Buildings (commercial)		
<u>Roofs</u>						
300 sq. ft. residential						
1500 sq. ft. commercial						
Firehosing	0.90	0.72	0.30	0.15	0.90	0.2 gals gas 900 gal water
Firehosing and detergent scrubbing	0.29	0.23	1.0	0.5	0.97	0.3 gals gas 700 gal water 3lb detergent
<u>Streets</u>						
350 sq. ft. residential						
150 sq. ft. commercial						
Firehosing	0.65	0.11	0.18	0.08	0.96	0.08 gal gas 350 gal water
Motorised flushing	12.0	2.2	0.023	0.01	0.98	0.15 " " 250 " "
Motorised sweeping	19.0	3.1	0.014	0.006	0.90	0.05 " " " "
<u>Other paved areas</u>						
300 sq. ft. residential						
150 sq. ft. commercial						
Firehosing	1.1	0.27	0.15	0.08	0.96	0.07 gal gas 300 gal water
<u>Unpaved areas</u>						
1000 sq. ft. residential						
300 sq. ft. commercial						
Power scraping or bulldozing	3.6	1.0	0.2	0.06	0.85	0.7 gal gas
Motor ploughing	16.0	5.5	0.04	0.01	0.85	0.3 " "
Gang ploughing	13.0	4.2	0.05	0.015	0.85	0.3 " "
Spading (by hand)	0.013	0.004	20.0	6.0	0.85	-
<u>Obstructions</u>						
400 sq. ft. residential						
100 sq. ft. commercial						
Firehosing	0.080	0.016	0.4	0.1	0.80	0.2 gal gas 1000 gal water
Firehosing and scrubbing	0.027	0.005	1.3	0.3	0.90	0.4 " " 1300 " "
<u>Outside Walls</u>						
400 sq. ft. residential						
200 sq. ft. commercial						
Firehosing	0.15	0.15	0.27	0.13	0.17	0.2 gal gas 800 gal water
Firehosing and detergent scrubbing	0.05	0.05	0.8	0.4	0.99	0.2 " " 600 " " 2lb detergent

RESTRICTED

Appendix B(i)

U.S. Studies on the decontamination of representative roofing materials (Reports CRLR 307 and 308)

Panels, 4 ft. x 4 ft. sloped at an angle of 15 degrees except for the built-up tar and gravel roofs which had a slope of 2 degrees, were each contaminated with 210 mgs of a "dust" of Tantalum 182 irradiated to about 5 mc/gm. (Half life 117 days, 1.22 Mev gamma, particle size distribution not available).

The general conclusions were that if water hosing is used at least 40 psig is needed to achieve 90% removal of the contamination.

Vacuum cleaning was also very effective on rough surfaces but it took about three times as long as high pressure hosing.

On smooth surfaces weathering (a 5 to 7 m.p.h. wind) removed 60% of the activity in one day and the wind and rain removed 90% in forty-seven days. Rough surfaces showed 30 to 40% removal of activity by weathering after seven weeks.

The results are shown in R.P. Sheet I and it is to be noted that the roofing materials used are in no way typical of British materials.

Decontamination of Radioactive Ta - 182 dust from various roofing materials.

Reports CRLR 307 and 308 (July/August 1953)

RESTRICTED

Appendix B(1)

R. P. Sheet I (Roof Panels)

Decontamination Method	Surface Material	Total Time Minutes unless stated	Total water gallons	% Decontamination
Low pressure hosing 8 p s i g	Rolled asphalt	2	10	98
	strip shingle	4	20	84
	corrugated metal	2	10	95
	built-up tar and gravel	4	20	23
Low pressure hosing and brushing	r. a.	2	10	96
	s. s.	3	15	88
	c. m.	1	5	98
	t. and g.	4	20	44
Hosing 24 p s i g	t. and g.	45 sec.	6.5	32
Firehosing 40 p s i g	t. and g.	60 sec.	12.5	98
High pressure hosing 50 p s i g	r. a.	15 sec.	3.5	88
	s. s.	30 sec.	7.0	96
	c. m.	15 sec.	3.5	100
	t. and g.	60 sec.	14	95
H. P. hot water and steam (Seller's Unit) 90 p s i g hot water 8.3 gpm.	r. a.	30 sec.	4.2	94
	s. s.	1 min.	8.4	69
	c. m.	30 sec.	4.2	97
	t. and g.	1 min.	8.4	91
Vacuum cleaning	r. a.	2.5		99
	s. s.	2.5		91
	c. m.	1.5		97
	t. and g.	2.5		98
Dry sweeping	r. a.	2		82
	s. s.	2		0.9
	c. m.	2		96
	t. and g.	2		12

Decontamination of Radioactive Ta - 182 dust from various roofing materials.

Reports CRLR 307 and 308 (July/August 1953)

RESTRICTED

Appendix B(ii)

Plumb Bob Trial on Unpaved Ground

In this trial an area about 1 mile from ground zero of a tower burst bomb was contaminated to a peak intensity of about 60 r.p.h. A square 500 ft. by 500 ft. was monitored by recorders who came out of a nearby underground shelter and it was decontaminated starting at about H + 48 hours by a team of men with equipment brought from outside the contaminated area. It was again monitored after decontamination.

The ground consisted of stony desert from which boulders and larger stones had been scraped before the trial. It therefore represented the most difficult type of unpaved surface to clean by earth moving techniques.

Equipment used

- 4 motor graders (2 inch cut)
- 2 motorised scrapers
- 1 bulldozer

Procedure A 40' x 40' square was first cleared by the motor graders: this was enlarged to 60' x 60' by a 10' pass all round (pushing windrows to the periphery) and finally extended to 100' x 100'. Several trips with the scrapers were necessary to remove the windrows.

Finally a 200' wide buffer zone was cleared around the 100' x 100' area making a total cleared area of 500' x 500'.

Another 100' x 100' area was cleared in the same way but a 3' high earth barrier was built up round its periphery instead of the buffer zone.

The results of the decontamination are shown below in terms of the percentage residual dose-rate at the centre of the square.

Area cleared	Average % residual dose-rate at centre of the cleared square
40' x 40'	39
60' x 60'	32
100' x 100'	24
500' x 500'	16
After second pass over central 100' x 100' area	11
Centre of 100' x 100' Area with 3 ft. high earth barrier around it.	16

U.S.A.E.C. Report ITR 1464 (14/2/58)

Operation Plumbbob (Nevada, summer 1957)

Evaluation of Countermeasures System Components and Operational Procedures (CD 11605)

/Duration

RESTRICTED

Duration of task of clearing 500' x 500' area - 3 hours

Average Protective Factor of operators of the equipment - 5

(from doses recorded on their film badges.)

U.S.A.E.C. Report ITR 1464 (14/2/58)

Operation Plumbbob (Nevada, summer 1957)

Evaluation of Countermeasures System Components and Operational Procedures (CD 11605)

RESTRICTED

Appendix B(iii)

Camp Stoneman Trials September 1956

The large deserted Military Camp Stoneman was used for this trial. Large areas of paved ground with different types of surface and huts with different types of roofing material were contaminated to an extent which was estimated to correspond to 1000 and 10,000 r.p.h. at H + 1 hours.

For this purpose a surface loading of fall-out simulant of 25 mg per sq. ft. per 1 r.p.h. at H + 1 i.e. 25 gms/sq. ft. to represent 100 r.p.h. and 250 gms/sq.ft. to represent 10,000 r.p.h. at H + 1 were chosen. It was later considered that this was much too heavy a contamination and the results were interpolated to 3000 r.p.h. at H + 1 but it was felt that they could not be extrapolated down to 300 r.p.h. at H + 1 without serious misgivings.

Two types of fall-out simulant were used, a dry powder and a slurry but both were in fact typical only of a landburst weapon as there was no transfer of radioactivity from the carrier particles into the solution or on to the surface contaminated.

The fall-out simulants were based on a solution of Lanthanum - 140 (half life 40.2 hours, 1.2 Mev gamma emission) which was mixed with the appropriate carrier material. The powdered simulant consisted of Camp Stoneman loam soil (40,000 lb used) impregnated with the La 140 solution: The slurry (30,000 lbs) was produced by impregnating dried harbour mud from San Francisco bay with the La - 140 solution and then adding an equal weight of water.

The results of various decontamination procedures on different types of surface in terms of effectiveness, rate of operation and man-hours effort are shown in Tables 5.1 to 5.6 reproduced from Report U. S. NRDL - TR- 196. The planning rates and effort include time required to set up the equipment and to move it from area to area and also include an adjustment for an estimated 75% efficiency in the productive effort.

Table 5.7 is also included; it contains data estimated on a similar basis for transferable or ionic fall-out from an off-shore water burst. The data in Table 5.7 have been estimated from laboratory experiments and some very limited data from two water burst trials.

U.S. NRDL - TR - 196 (27.12.57)

Cost and Effectiveness of Decontamination Procedures for Land Targets (Test at Camp Stoneman, California, September 1956) (CD 12030)

RESTRICTED

Camp - Stoneman Trials

Appendix B(III)

U.S. NRDL - TR - 196 (27.12.57)
 Cost and Effectiveness of Decontamination Procedures for
 Land Targets (Test at Camp Stoneman, California,
 September 1956) (CD 12030)

Table 5.1 Expected Recovery Performance on Asphaltic Concrete Exposed to Dry Contaminant

PROCEDURE	1000 r/hr Initial Standard Dose Rate				3000 r/hr Initial Std Dose Rate			
	Resid'l Std. Dose Rate	Effec- tiveness ^b	Plann'g Rate	No. of men	Resid'l Std. Dose Rate	Effec- tiveness ^b	Plann'g Rate	No. of Men
Column	r/hr	Residual Number	1000 ft ² hr	Man hrs ² 1000 ft ²	r/hr	Residual Number	1000 ft ² hr	Man hrs ² 1000 ft ²
Motorized Flushing Firehosing FH-HSD-FH ^a	1	2	3	4	5	1	2	3
	8-16 1-100 ^d 12-19	.01 .04 .01-.02	35 15 10	2 6-8 11-13	0.06 0.4-0.5 1.1-1.3	18-32 16-94 ^d 26-38	.006-.01 .02 .01	2 6-8 11-13

Table 5.2 Expected Recovery Performance on Portland Cement Concrete Exposed to Dry Contaminant

PROCEDURE	1000 r/hr Initial Standard Dose Rate				3000 r/hr Initial Std Dose Rate			
	Resid'l Std. Dose Rate	Effec- tiveness ^b	Plann'g Rate	No. of Men	Resid'l Std. Dose Rate	Effec- tiveness ^b	Plann'g Rate	No. of Men
Column	r/hr	Residual Number	1000 ft ² hr	Man hrs ² 1000 ft ²	r/hr	Residual Number	1000 ft ² hr	Man hrs ² 1000 ft ²
Motorized Flushing Firehosing FH-HSD-FH ^a	1	2	3	4	5	1	2	3
	6-12 ^e 19-34 6-11	.01 .02-.03 .01	35 15 10	2 6-8 11-13	0.06 0.4-0.5 1.1-1.3	8-27 18-35 9-14	.003-.009 .006-.01 .003-.005	2 6-8 11-13

^a Firehosing plus handscrubbing with detergent followed by a second firehosing.

^b Residual number, as a measure of effectiveness, is the ratio of residual standard dose rate/initial standard dose rate:

$$\frac{\text{column 4}}{\text{column 3}}$$

^c Effort, in man hr/1000 ft², results from dividing the number of men involved by the planning rate:

^d For specific activity data provided an extremely large confidence interval. This data from MF-MS-10F test results, and it is assumed that the MS operation did not add to the decontamination effectiveness.

Appendix B(111)

Camp - Stoneman Trials

Table 5.3 Expected Recovery Performance on Asphaltic Concrete Exposed to Slurry Contaminant

PROCEDURE	1000 r/hr Initial Standard Dose Rate			3000 r/hr Initial Std Dose Rate				
	Resid'l Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate $\frac{1000 \text{ ft}^2}{\text{hr}}$	Resid'l Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate $\frac{1000 \text{ ft}^2}{\text{hr}}$	No. of Men	Effort ^c Man hrs $\frac{1000 \text{ ft}^2}{\text{ft}^2}$
Motorized Flushing	44-58	.05	28	47-57	.02	28	2	0.07
Firehosing FH-HSD-FH	24-70 34-41	.03-.07 .04	9 9	50-74 36-42	.02 .01	9 9	6-8 11-13	0.7-0.9 1.2-1.4

Table 5.4 Expected Recovery Performance on Portland Cement Concrete Exposed to Slurry Contaminant

PROCEDURE	1000 r/hr Initial Standard Dose Rate			3000 r/hr Initial Std Dose Rate				
	Resid'l Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate $\frac{1000 \text{ ft}^2}{\text{hr}}$	Resid'l Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate $\frac{1000 \text{ ft}^2}{\text{hr}}$	No. of Men	Effort ^c Man hrs $\frac{1000 \text{ ft}^2}{\text{ft}^2}$
Motorized Flushing	35-52	.04	28	43-56	.01-.02	28	2	0.07
Firehosing FH-HSD-FH	36-55 ^d 8-62	.04 .01-.05	9 9	36-55 ^e 8-62	.01-.02 .003-.02	9 9	6-8 11-13	0.7-0.9 1.2-1.4

^a Firehosing plus handscrubbing with detergent followed by a second firehosing.

^b Residual number, as a measure of effectiveness, is the ratio of residual standard dose rate/initial standard dose rate:

^c Effort, in man hr/1000 ft², results from dividing the number of men involved by the planning rate: $\frac{\text{column 4}}{\text{column 3}}$

^d Inconsistent results provided the wide range.

^e The range was expanded and adjusted to equal the width and magnitude of the 1000 r/hr values.

RESTRICTED

RESTRICTED

Cost and Effectiveness of Decontamination Procedures for Land Targets (Test at Camp Stoneman, California, September 1956) (CD 12030)

Appendix B(111)
Camp Stoneman Trial

Table 5.5 Expected Recovery Performance on Roofs Exposed to Dry Contaminant

	1000 r/hr Initial Standard Dose Rate					3000 r/hr Initial Std Dose Rate				
	Residual Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Planning Rate 1000 ft ² hr	No. of Men	Effort ^c Man hrs 1000 ft ²	Residual Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Planning Rate 1000 ft ² hr	No. of Men	Effort ^c Man hrs 1000 ft ²
Column	1	2	3	4	5	1	2	3	4	5
<u>Corrugated Metal</u>										
Firehosing FH-HSD-FH ^a	29 5	.03 .005	3.9 4.8	2 5	0.5 1.0	30 12	.01 .004	3.9 3.9	2 5	0.5 1.3
<u>Tar and Gravel</u>										
Firehosing FH-HSD-FH ^a	38 10	.04 .01	1.5 1.8	4 7	2.7 3.9	38 31	.015 .01	1.5 1.8	4 7	2.7 3.9
<u>Roll Roofing</u>										
Firehosing FH-HS-FH	54 15	.05 .015	3.0 3.9	2 5	0.7 1.3	54 30	.02 .01	3.0 3.3	2 5	0.7 1.5
<u>Composition Shingle</u>										
Firehosing FH-HS-FH	60 31	.06 .03	3.0 3.0	2 5	0.7 1.7	70 46	.02 .015	3.0 2.7	2 5	0.7 1.8
<u>Wood Shingle</u>										
Firehosing FH-HS-FH	100 50	.10 .05	2.1 1.5	2 5	1.0 3.3	200 100	.07 .05	2.1 1.5	2 5	1.0 3.3

^aFirehosing plus handscrubbing with detergent followed by a second firehosing.
Residual number, as a measure of effectiveness, is the ratio of the residual standard dose rate/initial standard dose rate:
Effort, in man hrs/1000 ft², results from dividing the number of men involved by the planning rate: column 4/column 3.

RESTRICTED

Cost and Effectiveness of Decontamination Procedures for Land Targets (Test at Camp Stoneman, California, September 1956) (CD 12030)

Appendix B (iii)

Camp - Stoneman Trials

Table 5.6 Expected Recovery Performance on Roofs Exposed to Slurry Contaminant

Surface and Procedure	1000r/hr Initial Standard Dose Rate					3000 r/hr Initial Std Dose Rate				
	Residual Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate 1000 Ft ² hr	No. of Men	Effort ^c Man hrs 1000 Ft ²	Residual Std. Dose Rate r/hr	Effectiveness ^b Residual Number	Plann'g Rate 1000 Ft ² hr	No. of Men	Effort ^c Man hrs 1000 Ft ²
Column	1	2	3	4	5	1	2	3	4	5
<u>Corrugated Metal</u>										
Firehosing FH-HSD-FH	30 7	.030 .007	2.7 3.0	2 5	0.7 1.7	38 17	.013 .006	2.7 2.7	2 5	0.7 1.8
<u>Tar and Gravel</u>										
Firehosing FH-HSD-FH	55 45	.055 .045	1.5 1.8	4 7	2.7 3.9	55 50	.018 .017	1.5 1.8	4 7	2.7 3.9
<u>Roll Roofing</u>										
Firehosing FH-HS-FH	120 55	.12 .055	1.8 3.0	2 5	1.1 1.7	120 55	.04 .018	1.8 2.7	2 5	1.1 1.8
<u>Composition Shingle</u>										
Firehosing FH-HS-FH	250 170	.25 .17	1.8 2.4	2 5	1.1 2.1	250 200	.083 .067	1.8 2.4	2 5	1.1 2.1
<u>Wood Shingle</u>										
Firehosing FH-HS-FH	250 170	.25 .17	1.5 0.9	2 5	1.3 5.6	250 200	.083 .067	1.5 0.9	2 5	1.3 5.6

Firehosing plus handscrubbing with detergent followed by a second firehosing.

Residual number, as a measure of effectiveness, is the ratio of the residual standard dose rate/initial standard dose rate. Effort^c, in man hrs/100 Ft², results from dividing the number of men involved by the planning rate: column 4/column 3.

RESTRICTED

RESTRICTED

RESTRICTED

Appendix B(iii)

Miscellaneous Laboratory and Weapon Trials data on
Offshore Waterburst fall-out (activity transferable)

Table 5.7 Expected Recovery Performance on Paved Areas and on Roofs Exposed to Wet (ionic) Contaminant

Surface	Procedure	Range of ^b Effectiveness (Residual Number)	Planning Rate (1000 ft ² hr)	No. of Men	Range of Effort ^c (Man hrs/1000 ft ²)
<u>Pavements</u> Concrete or Asphalt	Motorized Flush'g	.50 - .75	27	2	.07
	Firehosing	.55 - .85	9	6 - 8	0.7 - 0.9
	FH-HSD-FH ^a	.35 - .55	9	11 - 13	1.2 - 1.4
	Heater Flaner ^d	.04 - .06	4 - 8	3 - 4	.4 - 1.0
<u>Roofs</u>					
Tar and Gravel	Firehosing	.20 - .30	1.5	4	2.7
	FH-HSD-FH ^a	.05 - .15	1.8	7	3.9
Roll Roofing	Firehosing	.65 - .85	3.0	2	0.7
	FH-HS-FH	.20 - .50	2.4	5	2.1
Comp. Shingles	Firehosing	.65 - .85	3.0	2	0.7
	FH-HS-FH	.25 - .55	2.4	5	2.1
Corrg. Metal	Firehosing	.60 - .90	2.4	2	0.8
	FH-HS-FH	.40 - .55	1.8	5	2.8
Wood Shingles	Firehosing	.75 - .85	2.4	2	0.8
	FH-HS-FH	.35 - .75	1.8	5	2.8

^aFirehosing plus handscrubbing with detergent followed by a second firehosing.

^bResidual number, as a measure of effectiveness, is the ratio of the residual standard dose rate/initial standard dose rate.

^cEffort, in man hours/1000 ft², results from dividing the number of men involved by the planning rate.

^dRestricted to surface removal of asphalt paving only. Greater rate based on use of skip loader for truck with debris. Lesser rate relies on 2 laborers to shovel debris into truck. The results of this destructive decontamination method shows that surface removal techniques are required to achieve low residual numbers.

U.S. NRDL - TR - 196 (27.12.57)

Cost and Effectiveness of Decontamination Procedures for
Land Targets (Test at Camp Stoneman, California,
September 1956) (CD 12030)

RESTRICTED

Home Office
Scientific Adviser's BranchThe Decontamination of Residential AreasApplication of U.S. performance data to a London DistrictJ. McAulayIntroduction

1. American data on the decontamination of large areas are reviewed in Paper CD/SA 96. The object of the present supplement is twofold:

- (i) To describe a method and chart for quick assessment of the equipment, manpower and time needed to decontaminate the pavements and streets in any built-up area under the wide range of conditions likely to be encountered in nuclear warfare and
- (ii) To apply the chart and the U.S. experimental data to the decontamination of a typical heavily populated residential area about 7 miles south of the centre of London.

2. CD/SA 96 also mentioned British plans for public control in a contaminated area to avoid radiation sickness and possible death. These plans assume an initial period of up to 48 hours in a radiological refuge: for the following week or two, when possible, the daily periods of exposure out-of-doors to perform essential services or to get necessities for the family, should be limited to 2 hours in the more heavily contaminated and 4 hours in the less heavily contaminated zones. It is also shown that about two thirds of the total dose accumulated by people who will have to remain in the contaminated zones will be acquired during these short outdoor periods. The decontamination of access routes from houses to the local distribution centres in built-up areas therefore offers a possibility of reducing the subsequent dose to the population by a factor of two or more and of permitting an earlier resumption of normal community life and activities.

3. The effort required to decontaminate a built-up area will depend not only on the local intensity of radiation at the time but also on the water supplies and on the type and amount of equipment, particularly of mechanised equipment, available. In most European towns equipment will be the limiting factor which will determine when the work can be started, how long it will take and how many men will be needed within the restriction that none of them should get more than a limited and agreed dose of gamma radiation.

4. The inner commercial centres of towns, where the resident population is small, frequently have pavements wide enough to permit the passage of mechanised street cleaning equipment in spite of obstructions such as poles, lampposts, post boxes etc. near the pavement edge. In many residential districts the pavement width may be 7 ft. or less so that mechanised equipment might have to be confined to the street: in such cases a small contribution from the residents would be required to brush or wash contamination from the sidewalks and the pavement in front of each house into the street gutter.

5. Major limiting factors are the starting time t_1 and the working shift length i.e. the number of hours $\Delta T = t_1 - t_2$ that men can work in a contaminated area before they get the allowed dose of radiation D_a . It is assumed that the gamma dose-rate will decay as a function of $t^{-1.2}$ during the first few weeks after the nuclear detonation. If R_1 is the one hour reference dose-rate and if the factor of protection afforded by any vehicle used for decontamination, then the dose D_a which may be incurred from t_1 to t_2 hours is

$$D_a = \frac{5 R_1}{f} \left\{ t_1^{-0.2} - t_2^{-0.2} \right\}$$

In the more heavily contaminated areas D_a may be accumulated in a single short work shift but in less heavily contaminated areas it will be possible for individuals to do repeated shifts separated by 8 or 12 hour rest periods: the work will take longer but will require less equipment and fewer men.

The allowed dose D_a

6. In the U.K. a Wartime Emergency Dose (WED) limit of 75r (100r under exceptional circumstances) has been accepted for Civil Defence life-saving operations. A limit has not yet been officially specified for decontamination operations and in this paper the 75r limit has been assumed to be applicable to the decontamination of access routes to permit the restoration of the essential activities of the community. Clearly, therefore, if the maximum use is to be made of specially trained men, the decontamination personnel must be given the best possible radiological protection during the early period of high dose-rate and rapid decay.

Transit dose

7. Decontamination crews will presumably operate from radiological shelters within the same district and they will not have to travel more than a few miles in an automobile at a speed of at least 30 m.p.h. Transit doses will therefore be negligible compared with the allowed dose D_a except in very heavily contaminated areas or where distances are more than 2-3 miles when the transit dose D_{trans} will have to be deducted from D_a . It may be calculated with sufficient accuracy for decontamination operations from the estimated transit time multiplied by the mean dose-rate over the distance to be travelled.

Starting time t , and duration of working shift (t_1-t_2)

8. Assuming a mean protective factor "f" over the transit and working time

$$\left(D_a - D_{trans} \right) f = 5R_1 \left\{ t_1^{-0.2} - t_2^{-0.2} \right\}$$

All variables other than time t can be grouped into one parameter

$$K = \left(\frac{D_a - D_{trans}}{5R_1} \right) f = \left\{ t_1^{-0.2} - t_2^{-0.2} \right\}$$

In Fig. 1 the shift duration $\Delta T = t_1 - t_2$ has been plotted against the starting time t_1 for a family of curves covering a range of likely or useful values of K . Fig. 1 can be used to determine any one of the variables ΔT , t_1 and K (and hence also of D_a) given the other two.

Heavily populated residential area in London

9. Details of a residential area to the north of Croydon and 7 miles south of the centre of London are given in Table 1. It consists mainly of rows of two or three storey terraced houses in streets at right angles to a main shopping and business thoroughfare: the latter consists of three storey terraced buildings with residences frequent in the upper floors.

Table I

Normal population		about 16,000
Total area (about 160 hectares)		399 acres
Streets length		73,000 ft.
Pavement widths		7 ft.
Area streets and pavements (67 acres)		2.92×10^6 sq. ft.
<u>Other details</u>		
Open spaces other than house gardens		20.0 acres
Church buildings (5)	plan area	0.67 "
School buildings (3)	" "	0.58 "
Halls (4)	" "	0.47 "
Public Library (1)	" "	0.09 "
Pavilions and Club Houses (4)	" "	0.24 "
Houses and shops (4,453)	" "	63.70 "
Balance: back and front gardens of houses and courts of larger buildings		about 246 acres.

Decontamination techniques and types of equipment

10. The U.S. data related to the decontamination of a large paved area (airfield) from which the fall-out was pushed by mechanised road sweepers into windrows and carted away to a prepared dump or it was washed into drainage channels, round the periphery of the area by motorised flushing machines or hand operated fire hoses.

11. There is little reliable information on the likely density of fall-out deposits in relation to intensity of radiation. In this paper a range of 20 to 0.05 gms per sq. ft. is assumed (20 to 0.05 mg/cm²). Thus over the pavements and streets of the London district under consideration, the amount of fall-out to be removed could range from 60 metric tons to a fraction of one ton.

12. British towns have a street drainage system which would greatly facilitate the disposal of all but the heaviest fall-out in sweeping it into the street gutters and then flushing or hosing it down into the drains. The U.S. rates of operation would be applicable to mechanised road sweepers with collector boxes and to motorised flushers, because of the time needed to empty the boxes or to fill the large water tanks. It is considered however that the U.S. rates for fire-hosing from a hydrant or pump and emergency reservoir would be too slow for British streets in which a road sweeper pushes the fall-out into the gutters and it is then hosed into the drains using the trailer pumps of the auxiliary fire service. (For very heavy fall-out the use of road sweepers with collector boxes would be preferable).

13. The performance data assumed in this paper for decontamination assessment are shown in Table 2.

Table 2

Equipment	Effectiveness % contamination removed	Number of crew per Unit	Rate of Operation sq. ft. per hour/unit	Assumed Protective Factor
A. Mechanised road sweeper U.S.	90	1	25,000	3
B. Motorised flusher (U.S.) 800 U.S. g.p.m. at 90 p.s.i.g.	98	2	30,000	2
C. Firehosing (U.S.) 100 g.p.m. at 80 p.s.i.g.	96	4 per nozzle	7,500	1.25 (see para 23)
D. U.K. Combined road sweeper and firehosing	96?	1 4 per nozzle	80,000 20,000	3 1.25

Application to a London District (Table 1)

(Area of streets and pavements 2.92×10^6 sq. ft)
Normal population 16,000

A. Mechanised road sweeper (U.S.) Crew 1. $D_a = 75r$ $f = 3$

14. If the job had to be completed in a single shift of 8 hours, fifteen machines and fifteen operators would be needed. If it could wait until decay permitted each man to do a repeat 8 hour shift after 12 hours rest then eight machines and eight men would be needed.

15. Estimated from the chart Fig. 1, the earliest starting times and the shift times for different one hour reference dose-rates are shown in Table 3.

Table 3

Mechanised road sweepers $f = 3$

Single 8 hour shift, 15 sweepers, 15 men			
R r.p.h.	K	Earliest shift hours	D_a r per man
10,000	.0045	H + 125 to H + 133	75
3,000	.015	H + 46 to H + 54	75
1,000	.045	H + 16 to H + 24	75
Two 8 hour shifts each for 8 men, 8 sweepers			
1,000	.030	H + 24 to H + 32	50
	.0157 (from Fig.1)	H + 44 to H + 52	26
			} 76
500	.060	H + 12 to H + 20	50
	.022 (from Fig.1)	H + 32 to H + 40	19
			} 69

16. If only a single machine were available and it was used continuously, the decontamination would take 117 hours. In an area of $R_1 = 1000$ r.p.h. and for $D_a = 75$ and $f = 3$, $K = 0.045$, it can be seen from Fig. 1 that if necessary a first 4 hour shift could start at H + 10 hours and decontamination could be completed by D + 5½ days. A total of eight to nine men would be needed, working in 4 hour shifts with 12 hour rest periods between, each being replaced by another as he reached his limit of 75r. Even so, at least three of the nine men would get less than half the allowed dose with a balance of 1½ "radiological lives" for other work.

17. It is clearly an advantage to use at least two mechanised sweepers and more where $R_1 \gg 1000$ r.p.h. since there is little difference between manpower needed to complete the work with eight machines during the third day and with one machine during the sixth day.

B. Motorised flusher (U.S.) Crew 2. $D_a = 75r$. $f = 2$

18. This technique is dependent on an ample supply of water. The water requirement is quoted as 500 U.S. gal. per 1000 sq. ft. so that for the total area of 2.92×10^6 sq. ft. of streets and pavements, 1.5×10^6 U.S. gal or 5700 m^3 of water would be needed (1 U.S. gal = 3.78 litres).

19. If the job had to be completed in a single working shift of 8 hours, 12 machines (24 men) would be needed. If it could wait until decay permitted each crew to work an additional shift (preferably in daylight) with a 12 hour rest period between, then the work could be done with 6 machines (24 men). The earliest starting times for different one hour reference dose rates have been estimated from Fig. 1 and are shown in Table 4.

Table 4

Motorised flusher $f = 2$

Single 4 or 8 hour shift for 24 men in 12 machines			
R_1 r.p.h.	K	Earliest shift hours	D_a r/man
10,000	.0030	H + 185 to H + 189	75
3,000	.010	H + 65 to H + 73	75
1,000	.030	H + 24 to H + 32	75
Two 7 or 8 hour shifts each for 24 men in 6 machines			
1,000	.020	H + 35 to H + 43	50
	.012 (from Fig.1)	H + 55 to H + 63	30
500	.040	H + 18 to H + 26	50
	.0184	H + 38 to H + 46	23

20. If only one motorised flusher were available and it was used continuously, decontamination of the 2.92×10^6 sq. ft. of streets and pavement would take about 98 hours. In an area where $R_1 = 1000$ r.p.h. and for $D_a = 75$ and $f = 2$, $K = 0.030$ it can be seen from Fig. 1 that a first 4 hour shift could start at H + 15 hours. A rough estimate can be made from Fig. 1 that not more than 20 men would be needed to decontaminate the whole area by about $D + 4\frac{3}{4}$ days.

C. Firehosing by hand (U.S.)

21. This technique of decontamination would have to be used where no equipment other than that of the fire service was available. The U.S. data are based on the use of $1\frac{1}{2}$ inch hoses fitted with $\frac{5}{8}$ inch nozzles, delivering 100 U.S. gals. per minute at 80 p.s.i.g., with an overall manpower requirement of 4 men per nozzle and a cleaning rate of 7,500 sq. ft. per nozzle per hour.

22. The total water requirement would be about 2.4×10^6 U.S. gals. (9100 m^3) which is about 60% greater than that needed for motorised flushing. Lack of water would thus be a major limitation on the speed of decontamination in districts with only firehosing equipment.

23. In a heavily populated district where buildings are often continuous on both sides of the street, there will be a significant reduction in the average dose-rate because of the areas already cleaned. The fractional reduction will depend also upon the depth of front gardens and the roof areas in line of sight from operations in the roadway. In the selected London district (Table 1) front gardens were 5 ft. deep and in 2 storey houses the amount of visible roof was equivalent to the addition of 15 ft. to either side of the road i.e. a centre strip of 40 ft. in a total equivalent width of 80 ft. would be cleaned and this should reduce the dose-rate ultimately to considerably less than half its original value. Since two and probably three out of the crew of four men/nozzle will be working most of the time manning the pump and hauling the hose in a

cleaned part of the road, an average protective factor of 1.25 has been assumed for men engaged in firehosing streets and pavements in a built-up area.

24. If the job had to be completed in a single shift of 8 hours, 50 nozzles, 200 men and a total rate of water consumption of 0.3 million U.S. gals/hour ($1130 \text{ m}^3/\text{hour}$).

Table 5

Firehosing single 8 hour shift $f = 1.25$
50 nozzles 200 men

R_1 r.p.h.	K	Shift hours	D_a r/man
3,000	.0063	H + 98 to H + 106	75
1,000	.0188	H + 37 to H + 54	75
500	.0375	H + 19 to H + 27	75

25. If 25 nozzles and hoses were available, the teams could work in two consecutive shifts for a dose of $150r$, the length of each shift being arranged so that each gets a dose of $75r$. Here $K_2 = \frac{150 \times 1.25}{5R_1}$ and $K_1 = \frac{75 \times 1.25}{5R_1}$.

The whole district could then be decontaminated in $\frac{2.92 \times 10^6}{25 \times 7.5 \times 10^3}$ or about $15\frac{1}{2}$ hours.

Table 6

Firehosing Consecutive Shifts $f = 1.25$
25 nozzles 2 x 100 men

R_1	K_2	Consecutive Shift hours	K_1	Individual Shift hours
3,000	.0125	H + 89 to H + 104 (15 hours)	.0063	ΔT_1 $7\frac{1}{4}$
			.0063	ΔT_2 $7\frac{3}{4}$
1,000	.0375	H + 32 to H + 47 (15 hours)	.0188	ΔT_1 $6\frac{1}{2}$
			.0188	ΔT_2 $8\frac{1}{2}$
500	.075	H + 16 to H + 31 (15 hours)	.0375	ΔT_1 $6\frac{1}{2}$
			.0375	ΔT_2 $8\frac{1}{2}$

D. Proposed British combined technique

26. This would be applicable to all but the heaviest fall-out deposits (i.e. much above $R_1 = 1000$). The decontamination would be carried out using a standard type road sweeping machine (without a collector box), which would sweep the fall-out into the street gutters and it would then be swept with firehoses down into the street drains: four $1\frac{1}{2}$ inch firehoses (each with a $\frac{3}{8}$ inch nozzle) could be fed by one existing type trailer pump of the British auxiliary fire service.

27. The road sweeper is assumed to afford protection by a factor $f = 3$. The rate of forward travel is normally just over 3 m.p.h. and assuming six passes over 40 ft. width of street and pavement and allowing about 25% of the time for servicing, the overall cleaning rate will be 80,000 sq. ft. per hour. The time required to sweep the whole area will be thus $2.92 \times 10^6 / 8 \times 10^4 = 36\frac{1}{2}$ hours.

28. Since firehosing in the open will follow behind the road sweeper it will not be realistic to start* decontamination earlier than about $H + 16$. For a one hour reference dose-rate, $R_1 = 1000$ r.p.h., $Da = 75$ $f = 3$, it can be estimated from Fig. 1 that three men each doing two 6 hour shifts with 12 hour rest period between, could sweep the whole area in about 36 hours getting doses of about 50, 40 and 30r respectively.

29. Firehosing would be started about $H + 17$: an average protective factor $f = 1.25$ (see paragraph 23) is assumed for men engaged in firehosing. A forward speed of about 1000 ft./hour per nozzle for driving fall-out along the street gutter down into the drains is considered to be reasonable. With one nozzle to each gutter and a paved width of 40 ft. this is equivalent to a cleaning rate of 20,000 sq. ft. per hour per nozzle.

30. One fire service trailer pump feeding 4 hoses and nozzles could keep pace with the road sweeper and clean the district in about 36 hours. In general, shifts of about 4 hours duration with a 12 hour rest interval will be preferable for this heavy manual work and unless illumination can be provided at night it will be desirable to limit firehosing to the hours of daylight.

31. Water consumption by the combined road sweeper and fire hosing technique would be $100 \times 60 \times 36 \times 4 = 0.86 \times 10^6$ U.S. gals or 3250 m^3 which, as one would expect, is considerably less than the amount needed either for the motorised flusher or for the firehosing technique alone.

32. If firehosing were carried out continuously with 4 nozzles from $H + 17$ to $H + 53$ (i.e. one hour behind the road sweeper), ~~96~~ ¹⁴⁴ crews each of 16 men (total ~~144~~ ¹⁴⁴ 96 men) working in ~~3~~ ⁴ hour shifts with 12 hours off, would be needed and of these, ~~three~~ ^{one} crews of 16 men would receive only about one ~~third~~ ^{half} of the allowed dose.

33. If firehosing were suspended during the night 5 crews of 16 men (total 80 men) using 4 nozzles could probably complete the decontamination by $D + 3\frac{1}{2}$ days - alternatively with two trailer pumps and 8 nozzles and 160 men, appropriate daylight shifts could be worked out from Fig. 1 to have the work completed by about $D + 2\frac{1}{2}$ days.

*In heavily contaminated areas the work should not start before 48 hours but shortage of equipment may make it desirable to start as soon as possible in some districts so that others will not have to remain contaminated for excessively long periods.

Table 7

Comparative Summary

Paved Area to be decontaminated
 2.92×10^6 sq. ft. (= 27 hectares)
 for $R_1 = 1000$ r.p.h. and $Da = 75r$

Technique	Equipment	Man hours	Time
A. Mechanised road sweeper (U.S.)	15 sweepers	$15 \times 8 = 120$	H + 16 to 24
B. Motorised flusher (U.S.)	12 flushers	$24 \times 8 = 192$	H + 24 to 32
C. Firehosing (U.S.)	50 Nozzles	$200 \times 8 = 1600$	H + 37 to 45
D. Combined U.K. road sweeper, trailer pump and firehoses	1 sweeper 1 trailer pump 4 nozzles	$3 \times 12 = 36$ $9 \times 16 \times 4 = 596$ total 612	H + 17 to 53

20

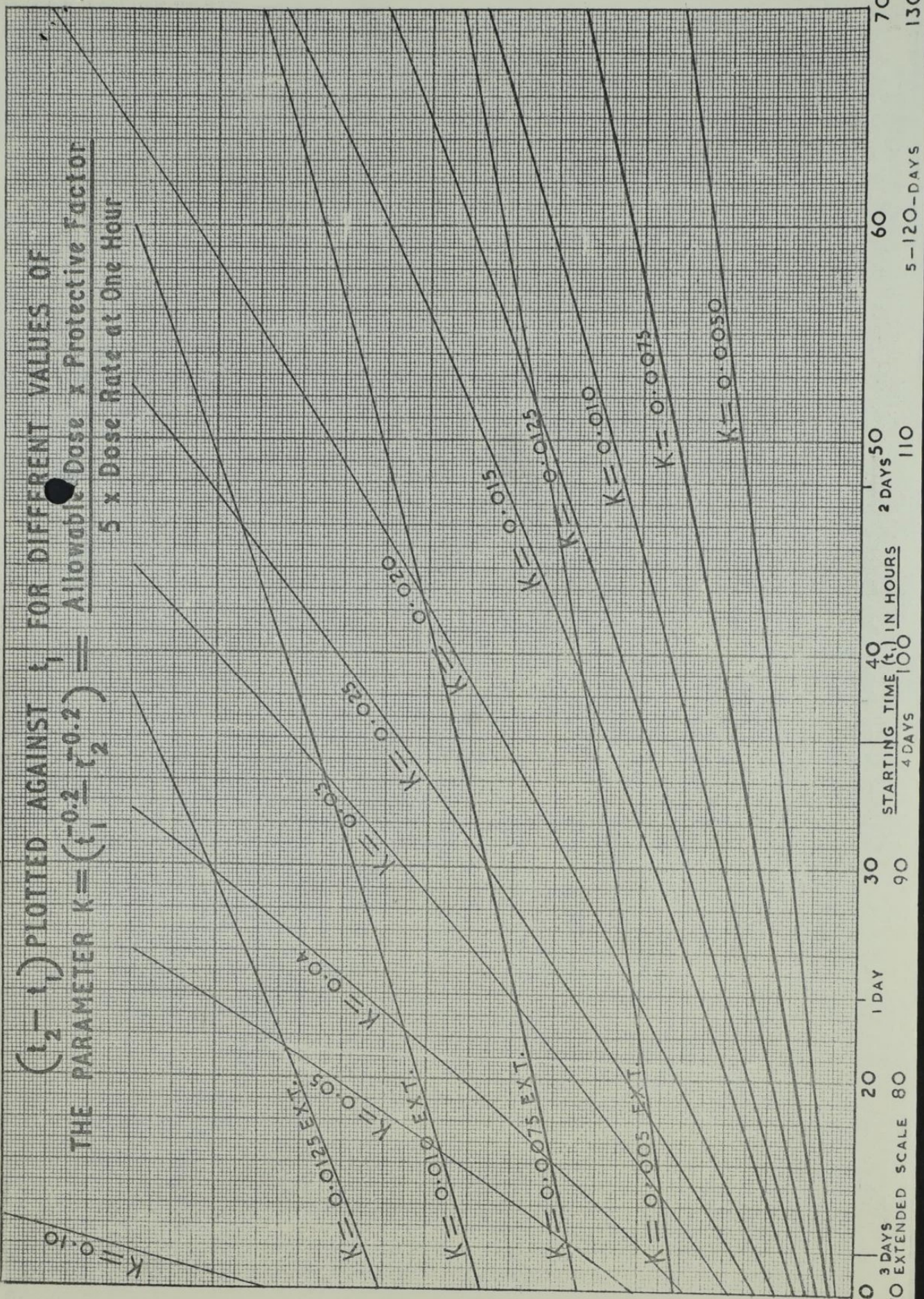
15

$(t_2 - t_1)$ HOURS

5

0

$(t_2 - t_1)$ PLOTTED AGAINST t_1 FOR DIFFERENT VALUES OF
 THE PARAMETER $K = \left(\frac{t_1 - 0.2}{t_2 - 0.2} \right)^{0.2} =$ Allowable Dose \times Protective Factor
 5 \times Dose Rate at One Hour



3 DAYS
70 EXTENDED SCALE 80

20 1 DAY

30 90

STARTING TIME (t_1) IN HOURS
4 DAYS 100

2 DAYS 50
110

60 5-120-DAYS
130

HOME OFFICE



SAN 59 0012/0008/001/

DECONTAMINATION

HO 338/141

W
1895

RELATED PAPERS

THE DECONTAMINATION OF
RESIDENTIAL AREAS.

Survived Review of Stantbury 9/12/71

DESTINATION	DATE	Initials	DESTINATION	DATE	Initials	DESTINATION	DATE	Initials
Dr. McAulay	25.11.59	P.B.						
Mr Leader-Williams	2.12.59	P.B.						
Mr Stantbury	3.12.59	P.B.						
Dr McAnally	4/12/59	P.B.						
Dr Purcell	5.10.60	P.B.						
Dr Purcell	7/10/60	P.B.						
Dr Purcell	14/11/60	P.B.						
Dr Purcell	7.4.61	P.S.						



HOF000480918



5.

THE QUEEN'S UNIVERSITY OF BELFAST

DEPARTMENT OF
PHYSICS



TELEPHONE:
BELFAST 30111

SAN 12/8/1

30th November, 1959.

Dr J. McAuley,
Scientific Advisers Branch,
Home Office,
Whitehall,
London, S.W.1.

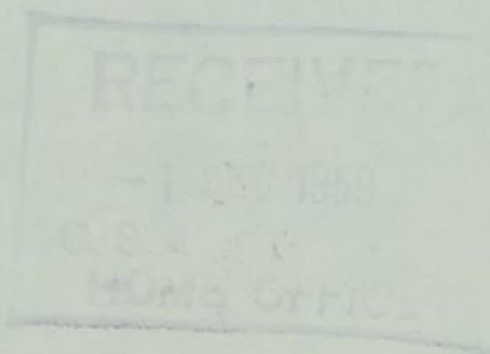


Dear Dr McAuley,

I have read through the paper
CD/SA 96 (restricted), and really
cannot criticise it at all.

Yours sincerely,

K. G. Emeleus



MINUTES

(Additional Minute-sheets should be filed on this side)

Doc 1 The Decontamination of Residential Areas CD/SA 96

I want to get this over to Porton and the Ministry of Supply S.A.C. as soon as possible. Porton have already started negotiating a large scale trial with Joint School of Nuclear Defence. I have left the U.S. data untouched as each lot has its own background. For Decontamination Study as a CD/SA perhaps we ought to boil the appendices down a bit. I should be happy to take the Camp Stoneham data B(iii) set and Plumbob B(ii) for this purpose. May I have your comments please.

Mr. Leader-Williams
Dr. Purcell

Intd. J.McA.
9/10/59.

I like this paper and I think we should send several copies to the D.G. with a cover note suggesting that the time has now come to set up some sort of decontamination organisation; that clearly the Fire Service and Local Authority sanitary departments are involved and that it is for consideration on whom the primary responsibility for the organisation should be put.

Dr. Purcell.

Intd E.L.W.
14/10/59.

I also like it. See few comments on pages 3,6,8. The possible value of earth barriers Appendix B(ii) deserves further study, is it worth putting in a few more words on this? Proceed with reproduction and distribution proposed.

Intd. R.H.P.
14/10/59

Dr. McAulay

A copy has been sent to Green (C.D.E.L.) and one to the Secretary of the S.A.C. Committee. ^{See file 9/16/59/1} Also report his being duplicated as a CD/SA (90 copies) for D.G. and H.H., Radiological Group. S.R.T.R. Scientific Advisers.

Intd. J.McA.
15/10/59.

Doc. 2. CD/SA 96 Final Version

Doc. 3. Dr. Purcell sends copies of CD/SA 96 to the D.G. & Council on decontamination in general. 6. 11. 59.

Doc. 4. Mr Jackson comments on CD/SA 96.

Dr. McAulay

25.11.59.

Doc. 5. Prof. Emelius acknowledges receipt of CD/SA 96.

Doc. 6. Note by the D.G. on action to be taken re decontamination

Dr. Purcell ^{RHP}
Mr Leader - Williams ^{me}

30.11.59.

Mr Stanbury ^{St.}

Dr. McAulay. JWA 11/12

Three copies of Dr. McAulay's paper on order for

D.G. H.K.L. 2/12/59.

3 copies sent to D.G. 15/12/59

G. Pepper 15/12/59.

Doc. 7. Dr. Woods would like to make decontamination paper cover wider scope than ^{at} present

Dr McAulay - I spoke to Woods on

11.12.59

phone - only decontam of residential areas wanted in discussion. He wants summary for the SAC I suggested pages 1-9. JWA 11.12

Doc 8. Note of discussion with C.D.E.E. reps. on the decontamination programme 14.3.60

Doc. 9. Col. Noel sends notes on decontamination

24.6.60

Dr. McAulay.

Doc. 10. CD/SA 96 Addendum Application of U.S. performance data to a London District.

Doc. 11. Dr. Nutton sends comments on CD/SA 96

5.10.60.

Dr. Purcell ^{RHP}

Doc. 12. Dr. Purcell replies to doc. 11.

7.10.60.

~~SECRET~~

Declassified Dec 19 88
J. E. Costello

SECRET

H0225/72

CD/SA(R)5

U.K. EYES ONLY

COPY NO. 16

HOME OFFICE

SCIENTIFIC ADVISERS' BRANCH

CO/SA 72

Casualty Estimates for ground burst
10 Megaton bombs

AUTHOR: EDWARD LEADER-WILLIAMS, 1 OCTOBER 1956

Summary

1956

Tentative estimates of casualties from up to 45 ground burst 10 megaton bombs on British cities are estimated for various conditions of shelter and evacuation.

Casualties from an attack aimed in the optimum way (to cause casualties) when there is no shelter or evacuation are found to range from over 2½ million killed by a single bomb to just over half a million per bomb by 45 bombs. The total evacuation of the evacuation areas shown in Fig. 8 is found to reduce fatal casualties from this attack by from 99 to 84% depending on the number of bombs. Similarly the evacuation of the priority classes (45%) combined with the provision of a high standard of shelter for the remaining inhabitants of the evacuation areas would reduce fatal casualties from this attack by from 99 to 86% depending on the number of bombs. These are the maximum savings that could result from these policies. If the enemy adjusted his attack so that all his bombs were aimed at reception areas, thus achieving the maximum casualties among the evacuated and/or sheltered population, the reduction in fatal casualties would range from 62 to 44% for the policy of 100% evacuation, and from 79 to 65% for the policy of 45% evacuation combined with shelter. In the event of either of these policies being adopted the enemy would probably make some adjustments in his attack without going as far as in the limiting case above of aiming all his bombs at reception areas. The saving in casualties would then be intermediate between the two sets of figures given above.

3. The shape and size of the fall-out pattern. The size and shape of the fall-out pattern for a ground burst 10 megaton bomb has been determined from the data presented at the February 1954 Tripartite conference*. The pattern consists of an ellipse with one apex at ground zero together with a circle centred a short distance down wind of ground zero. This pattern is reproduced as Figure 1 and the principal dimensions of some of its contours are shown in Table 1.

* 15-19 Feb. 1954, "Tripartite Conference: Effects of Atomic Weapons on Human Beings and their Environment", Washington D.C., AFSWP & USAEC

TABLE 1

Secret Principal dimensions of fall-out pattern from ground-burst
10 megaton bomb with a 15 knot wind

(This secret Tripartite conference included Canada, USA and UK.)

Dose rate (r/hr at 1 hour)	Down wind length of ellipse (miles)	Cross wind width of ellipse (miles)	Radius of ground zero circle (miles)	Down wind displacement of ground zero circle (miles)
5000	23	5.5	2.6	1.5
3000	33	7	3.1	1.7
2000	45	8	3.6	1.9
1000	72	11	4.5	2.3
500	115	16	5.7	2.6
300	160	22	6.8	2.8

Note: these data are from 1951 Jangle-S (1.2 kt) for downwind areas and 1952 Ivy-M (10.4 Mt) for upwind and crosswind of ground zero, with both distances and dose rates scaled by the cube-root of total yield (USNRDL-TR-1). This was incorporated into the June 1957 Effects of Nuclear Weapons edited by Glasstone. 1956 Redwing data showed upwind dose rates had been exaggerated 10-fold.

SECRET

U.K. EYES ONLY

IDEALIZED LOCAL CONTOURS
FOR RESIDUAL RADIATION

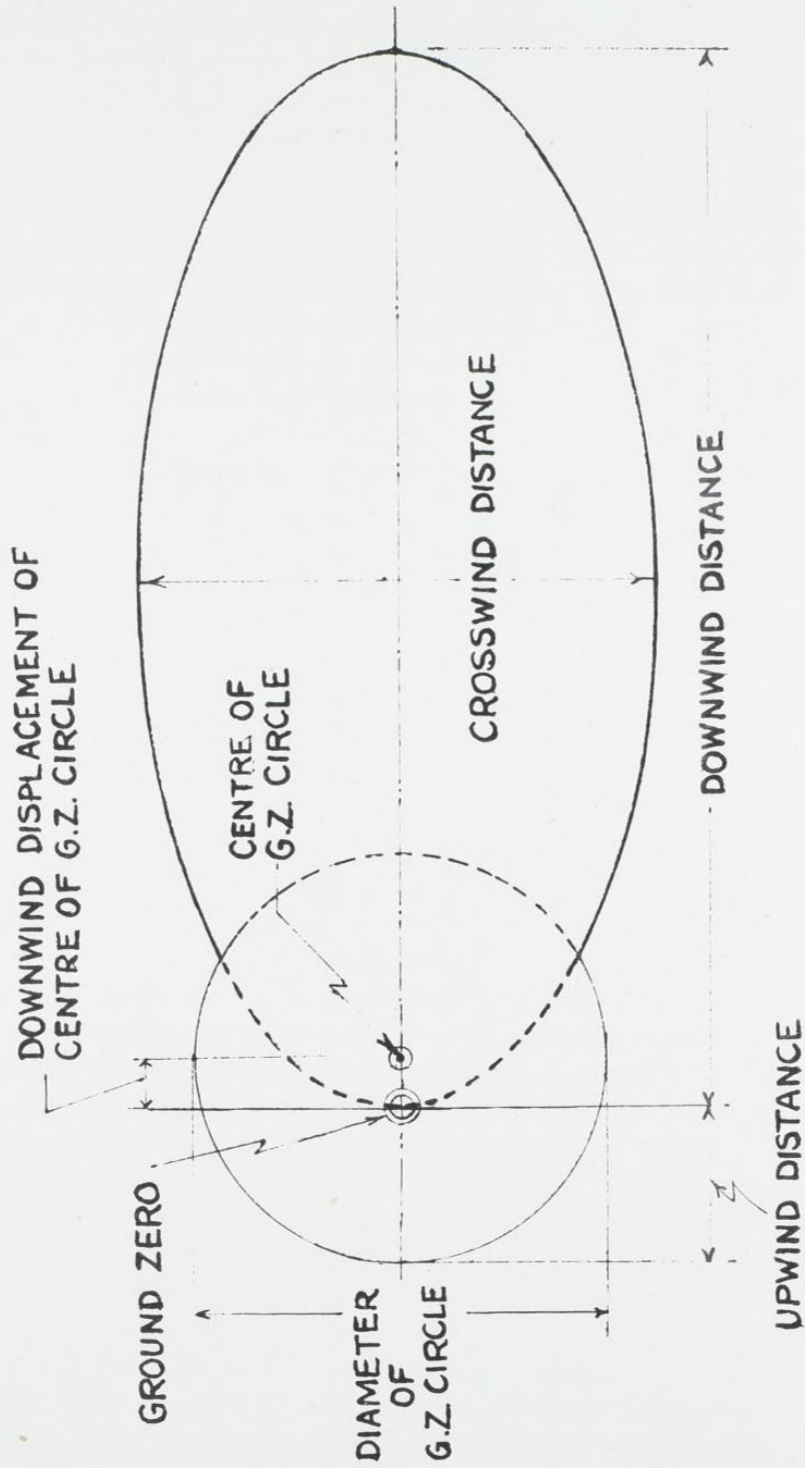


FIG. I

N
1467

HO 225/ 87

CLOSED UNTIL
/

SCIENTIFIC ADVISERS' BRANCH

THIS DOCUMENT HAS BEEN

CD/SA .87...

DOWNGRADED TO UnclassifiedAuthority in file No. SAC 5/25/11Date 1957 Initials plSome recent information from the United States about fall-out from ground burst megaton weapons1. Time of first arrival and duration

Until recently, Scientific Advisers' Branch had no firm information on the time of arrival and duration of fall-out from megaton explosions. Some information has been obtained from close-in and long-range fall-out measurements at the U.K. trials at Maralinga, but as these have all been in the Kiloton range the data are of limited value. Such advice as we have given, therefore, has been based on our own scientific appreciation of the phenomena and also on general information from the U.S.

On this basis we advised the Home Office Working Party on Operations in a Damaged Fall-out Area in May 1956 that there would be a period of from 15 to 30 minutes between bomb burst and the start of fall-out in the area around ground zero, and the proposals for fall-out warnings in the damaged area made by the Working Party were designed to enable householders to take advantage of this period to put out incipient fires etc. More recent data tend to confirm the validity of this advice.

We also advised that "In the damaged area around ground zero the fall-out (combined with spill-out from the column) will probably be down within the first hour after burst". This view is supported by a statement in paragraph 9.59 of the recently published U.S. book "The Effects of Nuclear Weapons", but more recent U.S. trials data indicate that this advice was a little optimistic and that appreciably longer fall-out times ought now to be assumed, even in the damaged area.

Data on these two aspects of fall-out have been given to us recently in two papers, one by Dr. Frank Shelton, Technical Director of the U.S. Armed Forces Special Weapons Projects entitled "Physical Aspects of Fall-out" and the other by E. A. Schuert of the U.S. Naval Radiological Defence Laboratory, in Report TR 139 - "A fall-out forecasting technique with results obtained at the Eniwetok Proving Ground".

On arrival times Dr. Shelton states "Fall-out from a detonation of the order of a megaton will begin to arrive on the ground over an area the order of the size of the visible cloud, almost like a blanket at about 15 to 20 minutes for a large yield surface burst on an island or presumably on land. Fall-out from a shot of the order of a megaton on a barge in water will begin to arrive at the surface at about 30-40 minutes".

[N.B. For the land or island shots the average particle size is greater than for water shots, and therefore the particles fall more quickly.]

"The above fall-out is exclusive of the vicinity of the crater and throw-out."

On fall-out duration, Dr. Shelton states "The radiation rate will build up on the ground under the cloud and reach a peak in about 100 minutes for a detonation of the order of a megaton".

Dr. Shelton gives a curve of deposition at a place 14 miles crosswind and slightly downwind of an explosion in the Pacific. This shows a starting time of nearly 30 minutes after burst, reaching a peak intensity at 100 minutes,

/with

This is Station 221.03, Bikini Atoll, at 68,600 feet from Redwing-Zuni - see weapon test report WT-1311, Fig 3.1

with fall-out effectively complete at about 120 minutes, the small additional fall-out over this extra period just about balancing the decay. It is stated that very small particles that do not contribute significantly to the radiation field continue to arrive for some hours.

Dr. Shelton gives a second curve for an undefined position downwind where the fall-out starts to arrive after $3\frac{1}{2}$ hours and reaches its peak in a further $3\frac{1}{2}$ hours. Again there is a further fairly lengthy period during which fall-out is continuously deposited at very low levels.

This long continued fall-out may have been the result of the low upper wind speeds and rather peculiar wind structure which obtained at the time (see Fig. 2 attached) and it is doubtful whether the effect would have been as noticeable in the case of the rather more definite wind structure (a fairly strong wind blowing in one major direction) which is more frequently found in this country. Even so it would be wrong to assume that it produces a significant civil defence hazard. Theoretically it produces an apparent slowing down in the rate of decay, but in practice this is masked by other effects which are dominant at this time and which tend to work in the opposite direction e.g. the presence of neptunium and neutron irradiated soil particles mixed in with the fission products, and the general uncertainty due to shifting of the fall-out by wind and - possibly - rain.

With regard to any possible contamination hazard to people exposed in the open during this period, theoretical calculations and trials experience alike have shown that this is small compared with the hazard of the external gamma radiation from the surroundings and can in fact be made negligible provided that a few simple precautions (wearing of gloves, shaking or brushing down or removal of outer garments, and washing of the face) are taken at the first opportunity.

It must also be recognised that only the most practised and knowledgeable observers will be able to assess with any accuracy when fall-out is complete; but no one will have any difficulty in fixing the time at which the peak dose-rate is reached.

For all these reasons it is clear that in practical civil defence it is the time to peak dose-rate which is important; any hazard from any subsequent fall-out from this explosion can be neglected.

(a) Time of first arrival

The first curve and the statement about arrival times quoted above are both consistent with the general physical model of the explosion which is assumed by Dr. Shelton in his paper and which is discussed in great detail by Schuert. This model is based (i) on rocket sampling measurements of radiation intensities in different parts of the stem and cloud, and (ii) on assumptions about the particle size distribution which was found to give satisfactory forecasts of the contamination patterns on at least three out of four megaton explosions in the last Pacific series.

(i) It has been established that there is negligible activity in the lower two-thirds of the mushroom stem, but that it is concentrated in the upper part of the stem and in the lower central one-third of the cloud when it is first stabilised at its maximum height. The activity is 30 times more concentrated at the centre than at the edge of the cloud at about $H + 7$ minutes when it first becomes stabilised. Of course, during these first minutes there is no fall-out because the upward forces are still greater than gravity.

/(ii)

This is
Redwing-Zuni
ship YAG40,
see WT-1317
Fig. 3.3

(ii) It is assumed that the largest particles, about 1000 microns (1 mm) in diameter, are concentrated in the space immediately above the top of the mushroom stem. This space is at an average height of about 60,000 ft. from the ground and 1000 micron particles take at least 10 minutes to fall through this distance. (Stokes' Law gives about 5 minutes but it is well established that for particles of this size the flow is turbulent and the rate of fall correspondingly slower.) Thus a total time of about 17 minutes elapses before the arrival of fall-out on the ground underneath the stem, which is only a few miles in diameter.

For a 10 MT ground explosion the radius of the stabilised cloud is 25 to 35 miles, and particles down to 500 microns in diameter appear to be confined to within half this radius i.e. to within about $12\frac{1}{2}$ to $17\frac{1}{2}$ miles from the centre of the stem, but in the lower one-third of the cloud. Spherical particles of this size take about 25 minutes to fall from 60,000 ft. and irregular shaped particles take much longer; thus the lapse of time before the arrival of such particles anywhere in the area up to $12\frac{1}{2}$ to $17\frac{1}{2}$ miles from ground zero (assuming no downwind shift of the cloud in this time) will not be less than 30 minutes and may well be very much longer.

(b) Duration of fall-out

Although the maximum size of particles assumed present at $12\frac{1}{2}$ - $17\frac{1}{2}$ miles from ground zero is 500 microns, smaller particles - down to 250 microns in size - are also present; and the duration of fall-out depends on the difference between the times of fall of these two sizes of particles. According to Schuert, 250 micron particles take between two and three hours to fall depending on their initial height in the cloud. If we subtract from this the time of arrival of the heaviest particles at this range we see that the duration of fall-out as given by this physical model is not inconsistent with Dr. Shelton's close range deposition curve. The low level of deposition which continues for some hours is undoubtedly provided by even smaller particles.

At long ranges (greater than 50 miles) the phenomena are much more complex. In the size range from 250 down to about 75 microns, particles are increasingly affected by such factors as turbulence, diffusion, wind shear etc., and they are falling from an increasingly greater range of heights. All these statistical variations tend to increase the time of deposition at any place roughly in proportion to the average time taken to travel the intervening distance. For the rather unusual wind conditions experienced during the Pacific tests Dr. Shelton states that the time from first arrival to peak dose-rate is always about equal to the time of first arrival, and his second deposition curve supports this statement, the time to first arrival and the time from arrival to peak dose-rate both being $3\frac{1}{2}$ hours.

British trial results with kiloton explosions tend to confirm the fact that build-up times are roughly proportional to the distance travelled for a given wind speed although, as would be expected from the much smaller initial clouds, the actual times are not as great.

2. Upwind Contamination

The advice given by Scientific Advisers' Branch to the Working Party was based on information exchanged at a conference early in 1954 which gave a dose-rate of 10 r.p.h. at H + 1 at a distance 9 miles upwind of ground zero. A corresponding contour of 50 r.p.h. at H + 1 at 6 miles was quoted publicly by Govr. Val Peterson. Having in mind the date of the conference it is obvious that the only experience in the U.S. of megaton explosions at that time was of the one in November 1952.

Some time after the megaton explosion of March 1954 we were told that the U.S. were now convinced that contamination in the damaged area was heavier than this and it was for this reason that we suggested the inclusion of the "very heavy" contours in the chart which was circulated with the Working Party's Report and also suggested a modification of the script of the new H bomb film to indicate that the green line (3 r.p.h.) at H + 1 might be anywhere from 5 to 20 miles upwind of ground zero.

We are now confronted with the new U.S. book "The Effects of Nuclear Weapons", which seems to indicate that the contamination is greater still, an indication which must be examined in detail.

Using the data in Table 9.71 for a 1 MT explosion, and scaling up to a 10 MT explosion by means of the principles enumerated in paras. 9.74 to 9.77 we arrive at the rather startling result that the 10 r.p.h. contour at H + 1 extends 26 miles upwind (30 miles for the ground zero circle radius less 4 miles for the downwind displacement of the ground zero circle).

Firstly it is important to realise that in making this calculation it is necessary to extrapolate beyond the range of figures given in Table 9.71. This is because both distances and dose-rate values have to be scaled up according to the cube-root law, and in order to find the value corresponding to 10 r.p.h. for a 10 MT explosion we have first to extrapolate to the distance corresponding to a dose-rate of $\frac{10}{\sqrt[3]{10}} = 4.65$ r.p.h. in the table for a 1 MT explosion, and then scale this distance (14 miles) up by $\sqrt[3]{10} = 2.15$ to reach a final figure of 30 for the ground zero circle radius. It is in the region of low dose-rates around ground zero, below those actually quoted in the table, that there is the greatest uncertainty not only in the experimental data but in the theoretical basis for the scaling laws, and for these reasons alone the result should be treated with some reserve.

Secondly it is instructive to compare this result with actual contamination patterns for large yield shots which have recently become available. One such pattern is given both in Dr. Shelton's and in Schuert's papers and it is reproduced in Fig. 1 attached to this paper.

Although dose-rates are not actually quoted on the diagram, there are sound reasons for assuming that the outer contour is certainly not greater than 10 r.p.h. at H + 1 and the distance of this contour in the upwind quadrant ranges from 10 to 20 miles from ground zero.

It is also possible to infer from the data that the relevant wind speed on that occasion was 5 to 10 m.p.h.; at higher wind speeds the degree of contamination upwind would have been less.

For the other three contamination patterns (two of which were from water bursts) the upwind limits are all below 10 miles.

**5.01 megatons,
87% fission
Redwing-Tewa,
Bikini Atoll, 20
July 1956
(fallout pattern
appears in
WT-1317, Fig.
4.9.**

In all the U.K. test explosions with kiloton bombs the dose-rate contours upwind have always been very steep indicating general agreement with the views given above, although it is impossible to use the data quantitatively.

As we have seen, the activity is concentrated initially in the upper part of the stem and the lower one-third of the cloud out as far as $12\frac{1}{2}$ to $17\frac{1}{2}$ miles which is the limit of the distance at which 500 micron particles (which take 30 minutes to fall) are found. Obviously this picture is modified by the downwind shift of the whole cloud during the time which elapses before the arrival of the fall-out on the ground (the E.N.W. "displacement of the ground zero circle"). In the case of the pattern reproduced in Fig. 1 this would be small because of the low upper wind speeds at the time of the trial (see Fig. 2), but for the average figure of 15 m.p.h. which is used as the basis of most of the E.N.W. data this would mean a displacement of about $7\frac{1}{2}$ miles in 30 minutes with a corresponding limit to the extent of contamination by 500 micron particles in the upwind direction of from 5 to 10 miles. Some of the smallest particles present at this range have most likely come from the extreme upwind edge of the cloud and have had to travel nearly 30 miles so that, again, a two-hour build-up time is not unreasonable.

We are forced, therefore, to conclude that the heavy upwind contamination for a wind speed of 15 m.p.h. which is deduced from Table 9.71 of E.N.W. is incompatible with the presently accepted physical model of the explosion which explains the megaton trial data so well.

For lower wind speeds, however, it is clear that contamination could extend further upwind; in the limiting case of still air some contamination could cover the whole area under the mushroom cloud - a radius of 25 - 35 miles around ground zero.

Conversely, of course, higher winds would result in less upwind contamination; for example with a wind speed of 30 m.p.h. it seems probable that only the largest particles (1000 microns) would fall upwind of ground zero and contamination would not extend outside the area of total destruction.

We therefore conclude that the three cases given in the chart attached to the report of the Working Party on the Control of Operations in the Damaged Area, where the upwind distance of the 3 r.p.h. line at H + 1 was given as 6, 11 or 16 miles provides a reasonable basis for Civil Defence planning, though it is recognised that in rare cases with very low wind speeds the upwind distance may be somewhat greater.

SA/N 6/6/1

G.R.S.

December, 1957.

WIND VECTORS FOR FALL-OUT
PATTERN AT FIG. 1

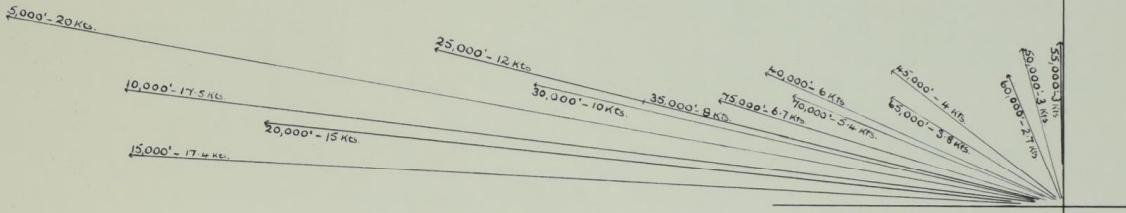


FIG. 2

TYPICAL FALL-OUT CONTOURS FROM A HIGH-YIELD
GROUND-BURST EXPLOSION IN THE PACIFIC (LOW WIND CONDITIONS)
*Interim Test Report ITR-1354, Fallout Studies at Operation Redwing, Fig. 3.22.
Land equivalent dose rates (R/hr) extrapolated back to 1 hour after burst*

NOTE: WT-1317 and Schuert's USNRDL-TR-139 both reproduce this 5.01 megaton 87% fission Redwing-Tewa fallout pattern, but with some hotspots omitted, and with a false (reduced) distance scale in Schuert's unclassified report



HO 225/101

(As a result of changing USA supplied fallout data, the UK gave up analysing distances and just concentrated on the fallout areas contaminated under ~15mph wind speeds. This 1960 paper by Stanbury explains data sources!)

N
1467

CLOSED UNTIL

1991

NOTE: these Confidential-classified reports by UK Home Office Scientific Adviser's Branch physicist George Reginald Stanbury, OBE (1903-73) refer to the 1957 edition of Glasstone's book *Effects of Nuclear Weapons* (based on nuclear test data for civil defence, not the false computer simulations later published).

Stanbury attended the 1952 Operation Hurricane UK nuclear test and analysed thermal and fallout data. This paper compares fallout areas in Glasstone and other sources like the Classified 1957 USA Capabilities of Atomic Weapons TM 23-200 and the 1959 UK Manual of C.D. v1 pamphlet 1, Nuclear Weapons booklet.

The latter shows that a 1 megaton fission surface burst gives 30 R/hr at 48 hours after burst over an area of ~50 square miles: this comes from Table 9.71 in Glasstone, 1957: the elliptical fallout belt for 15 mph wind is 22 miles long and 3.1 miles in maximum width, thus having an area of $(\pi/4)(22)(3.1) = 52$ square miles. For comparison, Fig. 4-14B in the Confidential American manual TM 23-200 Capabilities of Atomic Weapons, gives an area of just 28 square miles.

CONFIDENTIAL

CD 12960

CD/SA 101

THIS DOCUMENT HAS BEEN
 UNCLASSIFIED TO *Unclassified*
 Authority in file No. *54668 3/3/72* HOME OFFICE
 Date *1/9/80* Initials *VRB* SCIENTIFIC ADVISER'S BRANCH

Downwind fallout areas from ground-burst
 megaton explosions

- Information available in 1958
 - The U.S. publication "The Effects of Nuclear Weapons" **GLASSTONE, 1957 edition** paragraphs 9.71 to 9.73
 - The U.S. publication "Capabilities of Atomic Weapons" **TM 23-200** fig. 4-4B, prepared by the Armed Forces Special Weapons Project; originally highly classified but now downgraded to "Confidential". This is at present under revision.

A comparison of the various figures for a few dose rates is given in Table 1.

Table 1
 Areas of downwind contamination (sq. miles)

NOTE: at 1 Mt, TM 23-200 Capabilities gives half Glasstone's E.N.W. fallout areas for 300-3000 R/hr at 1 hr

Dose rate contour @ H + 1 r.p.h.	1 MT; 100% fission		10 MT; 100% fission	
	(i) E.N.W. & U.K. Nuclear Weapons Capabilities	(iii) Capabilities	(i) E.N.W. & U.K. Nuclear Weapons Capabilities	(iii) Capabilities
3000	54	27	540	650
1000	210	110	2100	1750
300	650	350	6500	5000
100	1500	1100	15000	18500
30	3500	3500	35000	43000

N.B. The Capabilities data is approximately summarised in the expression

$$AR = \frac{10^5}{P^{-1.2}}$$

NOTE: for 20 kt fission yield, Capabilities TM 23-200 Fig. 4-14A gives 80% of the fallout areas in E.N.W. 1957 for 10-3000 R/hr at 1 hr

Where A = area in sq. miles
 R = dose rate contour in r.p.h.
 P = power of weapon in MT

CONFIDENTIAL

(b) The fallout pattern (Triffet's Tewa fallout pattern from WT-1317.) This is Fig. 7 on page 80 of the 1959 Congressional Hearings and is stated to be for a 5 Mt explosion. No fission yield is actually given although, as the whole of the article in which this pattern appears is concerned with a 50% fission yield weapon, it seems reasonable to assume that this pattern is also intended for a 50% fission yield. (Redwing-Tewa, 5 Mt, 87% fission)

The 25 r.p.h., 100 r.p.h. and 500 r.p.h. contours have been integrated and the areas compared with those from Capabilities in Table 3.

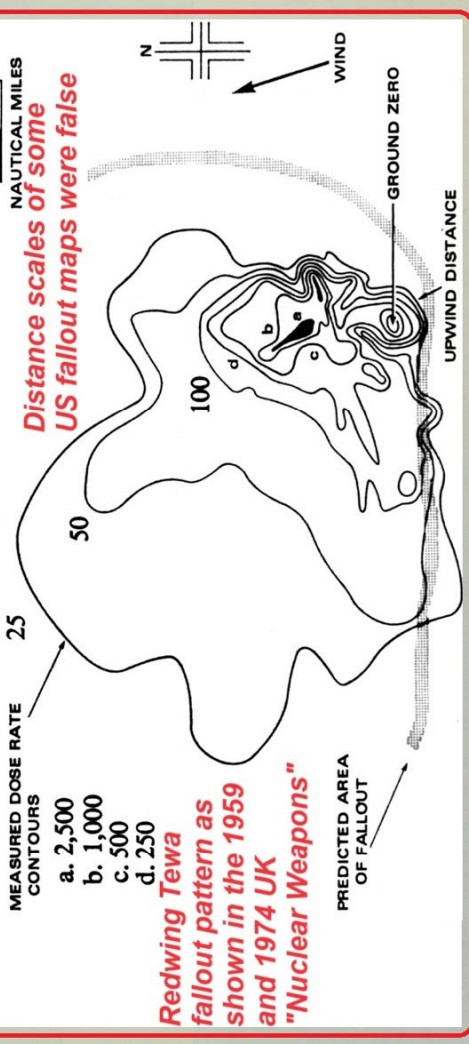
Table 3

Areas of downwind contamination (sq. miles)
Comparison of U.S. fallout pattern with Capabilities

Dose rate contour @ H + 1 r.p.h.	5 Mt; 50% fission	
	Redwing-Tewa Fig. 7, p.80 1959 Hearings	Capabilities
500	2,000	750
100	6,000	3,300
25	30,000	12,000

NOTE: when the Capabilities data is corrected from 50% to the real Tewa fission yield of 87%, the REAL fallout areas are ~2 times Capabilities data, i.e. equal to the 1957 E.N.W. data!

Comparison of fallout prediction with test results



G. R. STANBURY

November 1960.

CONFIDENTIAL

HO 227/ 51

CLOSED UNTIL
1993

N
1467

~~SECRET~~

FOR P.R.O.

HOME OFFICE
SCIENTIFIC ADVISER'S BRANCH

Ho 227/51

Regional Scientific Adviser's Conference
15th-17th May 1962The Soviet Strategic Air Threat to the United KingdomMr. H. S. Young
(Deputy Director, Joint Intelligence Bureau)

Although the title of my Talk today is the strategic air threat to the United Kingdom, I thought it would be more useful to you, as Scientific Advisers to the Home Office, to talk about the strategic air threat to the West as a whole. The threat to the United Kingdom is all too easy to understand. It is, however, the threat to the West, as a whole, which determines the likelihood of war.

The Russian development of weapons since World War II falls into three natural periods. It must be remembered that, in general, Russia fought only land battles in World War II. She did not fight an air war or a scientific war, and therefore she found herself at a grievous disadvantage at the end. For the first five years of the post-war period she devoted herself to copying Western equipments, particularly those for air defence, i.e. radars and fighter aircraft. She also began building a large submarine force, but as these submarines were all of short endurance, this arm was clearly intended to play a defensive role against aircraft carriers rather than to attack our lines of sea communication. The whole accent during this period was on defence, and the only offensive items tackled in this period were the copying of the American B.29 Super Fortress, which became the Russian Medium Bomber TU4, and the outstandingly high class nuclear weapon programme which resulted in the first Soviet nuclear explosion in the second half of 1949.

The next five years may be classified as the "belt and braces" period. Russia continued to produce new marks of orthodox equipment whilst initiating research programmes on novel weapons. During this period she began research and development on guided weapons of all types, and began her work on nuclear submarines. Great emphasis was put on surface-to-air guided weapons, and this again emphasises her defensive outlook. Her first heavy bombers - the Bear and the Bison - appeared during this period. This was the first indication of a strategic offensive capability.

During the next six years she has been phasing out the older weapons in favour of new ones. The first ICBM was fired in the middle of 1957, and the first space vehicle was launched two months afterwards. Obviously, the Russians were very impressed by the political impact of the first sputnik and they subordinated the I.C.B.M. programme to that of sputniks and lunar probes for the next year. In the meantime, the production of heavy bombers continued at a very slow pace, and this, combined with the easy progress of the I.C.B.M., indicated that the Russians were in no hurry to develop a strategic offensive capability. Another most interesting development during this phase has been the missile submarine programme, and the Russians are devoting very great efforts to this weapon system.

The present Soviet air order of battle amounts to about 200 heavy bombers and about 2,000 light medium bombers. Taking the likely attrition rate into account, the threat that this presents to America is very small whilst the threat presented to the United Kingdom and NATO installations in Europe is exceedingly great. It is interesting to note that the number of Soviet day and all-weather fighters is about 8,000 which again emphasises her defensive outlook.

The missile threat has much the same character. The number of I.C.B.M. launchers available is probably less than 20, and there is no certainty that the Russians have any operational missiles at all. The number of intermediate range

13.32

and medium range ballistic missile launchers probably amounts to about 300. Again, this poses a minor threat to the United States and a major threat to the United Kingdom and the NATO installations in Europe.

Bearing in mind that both sides almost certainly have an adequacy of fissile material, what does this all add up to? It probably means that the United States has a nuclear advantage of about 5 to 1. The quality of her deterrent is much higher, and there is much greater diversity. In terms of operations, it means that a Soviet first strike does not make sense, but an American first strike does. It means that Soviet strategy is:-

- (a) Deterrence of the United States against cities, and
- (b) Deterrence of Europe against everything.

On the assumption that the Soviets intend to continue their programme of I.C.B.M. production, they will certainly be able to have several hundreds of them in, say, five years. But it is far from certain that she intends to do this and, in view of the efforts which she is putting into her missile submarine programme, it may well be that, as with the heavy bombers, the number of land-based I.C.B.M.'s may remain small, and her major strategic missile threat may come from the sea.

During the discussion which followed, Mr. Leader-Williams said that the figures given by Mr. Young for the USSR Order of Battle did not agree with the data produced for the US Congressional Hearings. Mr. Young stated that the figures he had presented were almost certainly more recent than those quoted at the Congressional Hearings. The US now agreed with JIB's assessment. Sir Charles Ellis asked how US and USSR I.C.B.M.'s compared with regard to accuracy at comparable ranges. Mr. Young said that they had insufficient data on USSR weapons to make a valid comparison. Whilst the fall of missiles had been observed, one could not be sure of the aiming point. From the small amount of evidence available it appeared that the C.E.P. at operational ranges is of the order of 1 to $1\frac{1}{2}$ miles. Mr. Western asked where the 57 MT weapon fitted into the picture. Mr. Young said that we were not at all clear about this. It was delivered by the Bear and it was possible that the Russians had not yet developed a missile large enough to deliver it. It could possibly have been developed for Mr. Kruschov's Global Rocket. Its use in an anti-missile missile appears unlikely. Mr. Western asked if the Russians could deliver it to targets in the U.S.A. Mr. Young said that this was not possible with the Bear unless it could be refuelled several times en route. Mr. Garrard asked whether in view of their age we ought to disregard the TU-4's. Mr. Young replied that the TU-4 is probably obsolete and is being replaced by Beagle. Dr. Ollis asked how the attrition rates vary with the different methods of delivery. Mr. Young said that the US Air Defence would take a heavy toll of the Bear and Bison. The picture might change when the supersonic bomber came into service. The attrition rate by the UK Air Defence might well be lower. With regard to the ICBM, the USSR has a huge programme of Anti-ballistic Missile defence, but there are as yet no signs that missile sites have been constructed. The US is developing Nike-Zeus, but whether this will ever get into service is another matter. Its cost will be astronomical even by today's standards. In UK we consider the decoy problem to be insoluble. Now that the weight of megaton warheads can be much reduced, there is room in the missile for more decoy equipment. Warheads can be destroyed if the defence knows the design. Conversely, if the defence is known a warhead could be designed to outwit it. The problem is thus very complex and a successful solution is likely to prove very expensive.

HO 227/ 7

N
1467

CLOSED UNTIL
1991



HOME OFFICE
SCIENTIFIC ADVISER'S BRANCH

May 1960.

*in fact
in fact
in fact } have
copies*

1st Draft

The Adaptation of Basement Garages under New
Office Buildings for use as Shelters

by E. Leader-Williams

Introduction

1. At the present time the provision of car parking facilities on the site is a pre-requisite for planning permission for office blocks in the L.C.C. area and it is known that this also applies in Manchester and Liverpool. At least in the central part of the L.C.C. area, where sites are most valuable, the required parking facility is usually provided in the basement of the building, the basis being the provision of one parking space for every 2000 sq. ft. of office space.

It is understood that this garage space is at present being provided under new buildings in the L.C.C. area alone at the rate of 10,000 car spaces per year. This is equivalent to 250,000 shelter spaces per year on the last war basis of a space requirement for dormitory shelter of 10 sq. ft. per person. This space requirement may have to be increased somewhat for a long term occupancy, but it is used in this paper as a basis for cost calculations.

2. The plans of six new or proposed buildings in the West End have been examined and the following general observations apply -

(1) The sizes of the basement garages varied from 55,000 sq. ft. to 9,000 sq. ft. (i.e. 5,500 to 900 occupants on the basis of 10 sq. ft. per person).

(2) Two of the garages were in sub-basements with at least a basement, a ground floor and a roof over the whole garage. The remainder were in basements over portions of which the only cover was the ground floor slab. (In one case there was no cover at all over a small part of the basement garage space.)

(3) Access to the basement garages was normally by ramp, though in one case the car access was by lift. Where ramps were provided the normal

width was about 10 ft. which should permit of the entry of about 250 persons per minute. Use of both the in and out ramp would therefore allow an entry rate of about 500 persons per minute which should be adequate to fill most garage shelters in the assumed warning time of four minutes. Garages with lift access might have to be ruled out for shelter purposes unless they could be occupied in advance of the alert.

Blast protection

3. As they stand without alteration it is considered that basement garages under multi-storey steel or reinforced concrete framed office blocks would provide protection to their occupants from blast pressures up to about 10 p.s.i. (i.e. about four miles from a ground burst 10 Mt bomb). At this pressure the superstructure of the building would be very badly damaged, the panel walls would be blown in and the frame might be distorted, but the ground floor over the basement garage should not collapse. Moreover at this pressure it would not be essential to seal the shelter - American tests in Nevada suggest that the occupants of an unsealed shelter should not be injured at this pressure.
4. If the ground floor slabs over the basement garages were strengthened up to the old Grade A standard of strength but not of thickness (slab designed to carry a superimposed load of 1400 lb/sq. ft. at yield stresses) and the basement were sealed against the entry of blast by the provision of suitable blast doors etc. then it is estimated that the occupants should be safe against a blast pressure of at least 50 p.s.i. (i.e. 2 miles from a ground burst 10 Mt. bomb).
5. On the basis of the above estimates of strength, the relative blast casualties among a population in houses, in unstrengthened basements and in basements strengthened to grade A standard would be in the ratio of 1000 to 600 to 150.
6. It has been estimated (CDJPS(S)(54)5) that the extra cost of providing Grade A protection in the basement of an office building is about



5% of the cost of the building. Modern office buildings cost about 10/- per cubic ft. of space or say £5 per sq. ft. of floor area. The L.C.C. requirement for one car space per 2000 ft. of floor space therefore means that one car space would be provided from each £10,000 worth of building. One car space (250 sq. ft.) equals 25 shelter spaces at 10 sq. ft. per person, so that 25 shelter spaces would be provided for each £10,000 worth of building. If the provision of Grade A requirements costs 5% of the cost of the building, the structural provision for each shelter space would therefore cost £20.

Fall-out Protection

7. The two sub-basement garages referred to in paragraph 2 would have a protective factor exceeding 1000 over their whole area. The remaining basements would have a protective factor of more than 1000 over most of their area, but those portions which only had a ground floor slab overhead would be unlikely to have a protective factor exceeding 50. This wide discrepancy is clearly most undesirable in a fall-out refuge. One method of overcoming it, which is being advocated by the U.S. Authorities in the surveys of potential fall-out refuge which they are undertaking, would be by lines painted on the floor to indicate to the occupants which portions of the garage should, and which should not, be used as refuge. Alternatively walls could be constructed to shut off those portions of the basement not suitable for shelter though this could probably not be done without interfering with the peace time use of the garage.

8. If it is required to achieve a protective factor of 200 over the whole basement the ground floor slab would have to be thickened over those portions where it formed the only cover over the basement. For this a slab thickness of about 15 inches would be required to give a protective factor of 200 and the extra cost of this, as compared with the normal slab of about 6 inches thickness, should not exceed about 7/6d. per sq. ft. or say £4 per shelter occupant of those areas where roof thickening is required or £6 per occupant for P.F. of 1000.

9. The provision of a 50 p.s.i. (Grade A) slab over the basement would ensure a protective factor of at least 200 over the whole basement.

Protection from other Hazards

10. Fire. It is not considered likely that a fire storm, such as the one which caused so many casualties among the occupants of basement shelters in Hamburg, would result from a nuclear attack on a British city. Individual buildings, and whole blocks, would certainly be destroyed but modern office buildings of the type under consideration would be among the least likely to be involved. If the basement shelters are designed for 50 p.s.i. they will have to be sealed against the entry of blast and should therefore provide complete protection from fire even if the building over and the surrounding buildings are engulfed in a conflagration. If they are designed for 10 p.s.i. and are therefore not sealed there would be some fire hazard to the occupants, but it would be small and they might have time to seek alternative accommodation if their building appeared likely to be engulfed.

11. Flooding. Basements in low-lying parts of London would be in danger of flooding from a ground burst bomb which breached the Thames. However the crater would take some time to fill and the occupants should have plenty of time to leave before the floods threatened them. Damage to the building over the shelter, with consequent breakage of water mains, might pose a slow flooding risk. However there were few records of this type of incident in the last war and it is considered that the risk is trivial in comparison with the risks of blast and fall-out.

Ventilation

12. The normal* L.C.C. requirements for the ventilation of basement and sub-basement garages are that natural ventilation should be sufficient to provide for three air changes per hour and in addition mechanical ventilation

*In exceptional cases, where natural ventilation cannot be provided, an additional mechanised plant, capable of providing three air changes per hour, must be provided and must be capable of running should a failure occur in the principal source of power supply.



independent of any ventilating plant for other parts of the building should be provided sufficient to give three air changes per hour. The openings (amounting to not less than $2\frac{1}{2}\%$ of the area of the floor of the garage) required for natural ventilation are normally provided by the ramp entrances to the garage, which are closed by gates of the lattice type to permit a free flow of air.

13. If the garage were used as an unsealed 10 p.s.i. shelter (see para. 3) then it is considered that natural ventilation (where provided) will be adequate. Moreover the air speeds involved in this natural ventilation are so low that there is little risk of dangerous fall-out particles being carried into the shelter by the ventilating air. Where natural ventilation is not provided, the requirement for a second means of ventilation, independent of the main source of supply, should ensure adequate ventilation if the garage is used as a shelter.

14. It therefore appears that only if the garage is naturally ventilated but is intended for use as a sealed 50 p.s.i. shelter (see para. 4) will there be any requirement for additional ventilation equipment. It is estimated that stand-by generators to provide the necessary power for this and for a degree of lighting would cost about £5 per shelter space.

Standard of Shelter to be adopted

15. The alternatives appear to be either to use the buildings virtually as they are as 10 p.s.i. shelters or to strengthen the ground floor slabs to provide Grade A (50 p.s.i.) shelters.

16. If the former course is adopted the only structural alteration worth consideration would be the thickening of unprotected parts of the ground floor slab to provide a protective factor of 200. The cost of this would be unlikely to exceed an average of £1 per shelter space (assuming that an average of 75% of basement garage space had a building over it and not just a ground floor slab). On the whole this is not considered to be

worthwhile expenditure. It would add nothing to the blast resistance of the shelter and the same effect as far as fall-out is concerned could be achieved, without cost, by excluding the use as shelter of inadequately protected parts of the basement.

17. The existing provisions for ventilation should be satisfactory for 10 p.s.i. shelters, and the only provisions which would have to be made in peacetime would therefore be the provision of standby generating plant for lighting purposes and the provision of water storage for the shelter occupants. These are comparatively trivial provisions which could do little to promote public confidence in the buildings as shelters and there would seem to be little justification for making them at the present time. If nothing is done we shall still be accumulating potentially useful shelter space at the rate of about 200,000 shelter spaces per year in the L.C.C. area alone, and the provision of standby generating capacity and water storage could well be left till war seems more imminent.

18. The strengthening of the ground floor slabs to 50 p.s.i. (Grade A) would cost about £20 per shelter space and, since the shelters would be sealed, provision would also have to be made for standby generating equipment to work the ventilation system in event of power failure. The cost of this and the other measures required (e.g. water storage) should not exceed £5 per shelter space, so that the total cost of providing really first class shelter would be about £25 per head. If this were applied to all the new buildings in the L.C.C. area alone it would entail an annual cost of about £6 million.

N
1466

HO 228/23

CLOSED UNTIL

1990

NOTE: this report follows from the "Report of a course given to university physics lecturers at the Civil Defence Staff College 8-11 July 1957" (UK National Archives doc. HO 228/21) which contains papers by Frank H. Pavry on blast data including height of burst effect curves, A. G. McDonald on the contribution of scattered thermal radiation (depending on the field of view of the sky), etc.

~~CONFIDENTIAL~~

A12/X23

THIS DOCUMENT HAS BEEN
DOWNGRADED TO *Unclassified*
Authority in file No. *SAG 79 3/3/1*
Date *7-1-81* Initials *W. W.*

HOME OFFICE

SCIENTIFIC ADVISERS' BRANCH

REPORT OF A CONFERENCE OF THE REGIONAL SCIENTIFIC
ADVISERS FOR CIVIL DEFENCE, HELD AT THE CIVIL
DEFENCE STAFF COLLEGE, SUNNINGDALE PARK,
12th to 14th MAY, 1959.

October, 1959.

~~CONFIDENTIAL~~

CONFIDENTIAL

Report of a Conference of the Regional Scientific
Advisers for Civil Defence, held at the Civil Defence
Staff College, Sunningdale Park, 12th to 14th May, 1959.

The Conference was attended by Regional Scientific Advisers in England and Wales and Northern Ireland, by Regional Directors of Civil Defence and Officers of a number of Departments. The following were present for the whole or part of the proceedings:-

Scientific Advisers

Professor G. E. Coates, M.A., D.Sc., F.R.I.C.	Northern Region
Professor W. Bradley, D.Sc., Ph.D., F.R.I.C.	North Eastern Region
Professor L. F. Bates, Ph.D., D.Sc., F.R.S.	North Midland Region
Professor D. D. Eley, M.Sc., Ph.D., Sc.D.	" " "
Professor L. Hunter, D.Sc., Ph.D., F.R.I.C.	" " "
B. C. Saunders, Esq., M.A., Sc.D., D.Sc.	Eastern Region
Sir Charles Ellis, B.A., Ph.D., F.R.S.	London Region
Emlyn Williams, Esq., B.Sc., Ph.D., F.R.I.C.	" "
G. E. Watts, Esq., M.A., Ph.D., B.Sc., F.R.I.C.	South Eastern Region
N. Pentland, Esq., M.Sc., Ph.D., F.Inst.P.	" " "
E. G. Cowley, Esq., M.Sc., Ph.D., F.R.I.C.	" " "
H. W. Thompson, Esq., C.B.E., M.A., D.Sc., F.R.S.	Southern Region
Professor W. E. Garner, C.B.E., D.Sc., F.R.S.	South Western Region
Professor F. C. Frank, O.B.E., D.Phil., F.R.S.	" " "
J. W. Cook, Esq., D.Sc., Ph.D., Sc.D., F.R.S.	" " "
Professor G. K. Conn, M.A., Ph.D.	" " "
Professor F. Llewellyn Jones, M.A., D.Phil., D.Sc.	Wales
S. T. Bowden, Esq., D.Sc., F.R.I.C.	"
Professor M. Stacey, D.Sc., Ph.D., F.R.S.	Midland Region
Professor P. B. Moon, M.A., Ph.D., F.R.S.	" "
Professor J. R. Squire, M.A., M.D., F.R.C.P.	" "
A. F. H. Ward, Esq., M.A., Ph.D., F.R.I.C.	North Western Region
Professor J. Diamond, M.Sc., Wh.Sc., M.I.Mech.E.	" " "
Professor K. G. Emeleus, M.A., Ph.D.	Northern Ireland
Professor H. B. Henbest, B.Sc., Ph.D., D.I.C.	" "

Regional Directors

Major General S. Lamplugh, C.B., C.B.E.	Northern Region
J. R. S. Watson, Esq.,	North Eastern Region
Rear Admiral A. D. Torlesse, C.B., D.S.O.,	North Midland Region
Rear Admiral W. L. G. Adams, C.B., O.B.E.,	Southern Region
Major General J. S. Lethbridge, C.B., C.B.E., M.C.	South Western Region
Major General R. B. B. Cooke, C.B., C.B.E., D.S.O.	Wales
Air Marshal Sir Lawrence Pendred, K.B.E., C.B., D.F.C.	Midland Region
Lt. General E. N. Goddard, C.B., C.I.E., C.B.E., M.V.O.	
	M.C.
Lt. General Sir Alexander Cameron, K.B.E., C.B., M.C.	North Western Region
Captain K. L. Harkness, D.S.C., R.N.	South Eastern Region
	London Region

Home Office

Sir Charles Cunningham, K.B.E., C.B., C.V.O.
General Sir Sidney Kirkman, G.C.B., K.B.E., M.C.
Major General S. F. Irwin, C.B., C.B.E.
J. S. Paterson, Esq., C.B.E.
Lt. Colonel A. J. Batchelor, M.I.Mun.E., M.Inst.H.E.
K. P. Witney, Esq.
R. H. F. Firth, Esq.
M. G. Russell, Esq.
Major General F. R. G. Matthews, C.B., D.S.O.
Air Commodore C. J. Luce, D.S.O.
Surgeon Captain J. G. Holmes, O.B.E., M.A., M.D., R.N.(Retd.)
H. K. Black, Esq., B.Sc., Ph.D., D.I.C., F.R.I.C.
Miss I. M. Gibson

CONFIDENTIAL

Ministry of Supply

Sir Owen Wansbrough-Jones, K.B.E., C.B., M.A., Ph.D.

Ministry of Agriculture, Fisheries and Food

A. C. Sparks, Esq.
J. G. Carnochan, Esq.
G. Wortley, Esq., M.A., B.Sc.
Brigadier J. A. Mullington, O.B.E.

Ministry of Health

D. Thomson, Esq., M.D., D.P.H.
L. H. Murray, Esq., O.B.E., M.D., D.P.H.

Air Ministry

E. A. Lovell, Esq., O.B.E., B.Sc., A.Inst.P.

Admiralty

V. H. Taylor, Esq., B.Sc., A.Inst.P.

Ministry of Home Affairs, Northern Ireland

Captain C. C. McCreight, M.B.E.

Home Office, Scientific Advisers' Branch

R. H. Purcell, Esq., C.B., Ph.D., D.I.C., F.R.I.C.
E. Leader-Williams, Esq., B.Sc., A.M.Inst.C.E.
G. R. Stanbury, Esq., B.Sc., A.R.C.S., F.Inst.P.
D. T. Jones, Esq., M.A., B.Sc., F.S.S.
J. McAulay, Esq., D.Sc., A.R.T.C., A.R.I.C.
A. G. McDonald, Esq., B.Sc., A.R.C.S.
T. Martin, Esq., M.Sc., D.I.C., F.Inst.P.
A. M. Western, Esq., M.A., B.Sc.
A. D. Perryman, Esq., B.Sc.
E. Hutchings, Esq.
Miss H. Duddy

PROGRAMME OF THE CONFERENCE

Tuesday, 12th May

Conference Assemblies

- | | | |
|-------|--|-------------------------|
| 20.30 | Introduction by the Under Secretary
of State | Sir Charles Cunningham |
| | Science and Defence, past, present
and future | Sir O. Wansbrough-Jones |

Wednesday, 13th May

- | | | |
|-----------------|---|---------------------------------|
| 09.30 | Welcome by the Commandant | Major General F. R. G. Matthews |
| 09.35 | Opening Address by the Chief
Scientific Adviser | Dr. R. H. Purcell |
| 09.45-
11.00 | Working Party on the Operation of
Scientific Teams at Region and Below. | |
| | (i) Introduction of the First Report on
Operations at Regional level. | Dr. R. H. Purcell |
| | (ii) Discussion of the Report by Regional
Scientific Advisers and Regional
Directors. | |
| 11.00-11.20 | COFFEE | |
| 11.20-
12.20 | Part III Training of Scientific Intel-
ligence Officers | |
| | (i) Regional Courses and Exercises based
on the Easingwold Course. | Mr. T. Martin |
| | (ii) Local Authority Exercises,
Exercise "Arc". | Mr. E. Leader-Williams |
| 12.20-
12.45 | Summing up of the morning's proceedings
by the Director General | General Sir Sidney
Kirkman |
| | LUNCH | |
| 14.15-
14.35 | Radiation Tolerance Doses in Civil Defence.
Position reached since the last Conference | Mr. G. R. Stanbury |
| 14.35-
15.15 | Deployment of Civil Defence Forces in
relation to Radio-activity. | Mr. E. Leader-Williams |
| 15.15-
15.45 | The Operational Implications of Serial 8 | Mr. K. P. Witney |
| 15.45-
16.15 | TEA | |

Wednesday, 13th May (contd.)

- 16.15- Study "Pikadon". Presentation of the Staff College
17.10 position at Sub-Region at H + 2 and
H + 4 following a $\frac{1}{2}$ M.T. bomb on
Newcastle.
- 17.10- Discussion of Serials 7 - 10. Mr. G. R. Stanbury
17.45 to open

Thursday, 14th May

Scientific aspects of the Problem of
living in an area contaminated by
Radio-active Fall-Out.

- 09.30- (i) Survey of Protection against Fall-Out Mr. D. T. Jones
10.00 afforded by Houses and other
Buildings.
- 10.00- (ii) Radio-active Decontamination. Dr. J. McAulay
10.30
11.00
- 10.30- (iii) Discussion on Serials 12 and 13.
11.00
- 11.00-11.30 COFFEE
- 11.30- (iv) Food and Agriculture Mr. G. Wortley
12.15
- 12.15- (v) Food Monitoring Brigadier J. A. Mullington
12.45
- LUNCH
- 14.15- (vi) Discussion on Serials 15 and 16.
15.00
- 15.00- Fire Problems after a Megaton Explosion Mr. G. R. Stanbury
15.45 Study "Torquemada".
- 15.45- Conclusion
16.00
- 16.00 TEA. Conference disperses.

MR. LEADER-WILLIAMS: We certainly may be, but a limit would soon be reached because of the time taken in giving first aid and in delivery to the ambulances.

DR. PURCELL: I would have thought that Professor Squire was absolutely right in saying that we must make more use of private motor cars to carry the injured.

DR. MURRAY: I imagine the figures quoted do not include private cars; possibly they could be used.

MR. WITNEY: We were working on that basis. The station-wagon type of car could certainly be used, and ordinary cars could be used for sitting cases.

Thursday, 14th May.

XIV MR. JONES described a Survey of the Protection against Fall-out afforded by Houses and Other Buildings. He said:

This work was begun in 1956 when the White Paper on Civil Defence (Cd 9691) called for a sample survey to be made to find the level of protection against fallout which houses and other buildings could provide. The survey of private houses was started in 1957 and has now been completed. You will have had a paper describing the results of that survey - CD/SA 89.

Private Houses. The Home Office obtained the co-operation of the Local Authorities in eleven urban and rural districts which were considered to represent typical reception areas in the country. None of the large conurbations was included; the populations in all cases were less than 100,000, in most cases considerably less. The districts were:

Carlisle, Chesterfield, Exeter, Harrogate, Kirkcaldy, Perth, Wellingborough, Wrexham, Chelmsford, Witney and St. Boswells.

The Authorities were provided with a table which gave the protective factors of typical houses. Their task was to take a census of houses of various types and render a return of the number of households having given protective factors. On the whole the results showed that factors were lower than expected. The table on page 5 of CD/SA 89 shows that many households would have factors less than 40.

The Authorities were asked to consider three possible schemes of protection. Under Scheme A householders would stay in their own dwellings; under Scheme B they could move, if they occupied part of a building such as a flat, into the best part of the building; and under Scheme C they would make use of an underfloor trench in their own premises - if this were feasible.

Some of the outstanding results showed that in rural districts 45% had factors less than 25, 40% less than 40, and 97% less than 100. For rural districts under Scheme C, the corresponding percentages were 35%, 57% and 76%. In urban districts the corresponding percentages were 31%, 57% and 90% under Scheme A, and 11%, 40% and 52% under Scheme C. Combining rural and urban districts with appropriate weighting we found 'natural' estimates under Scheme A to be 36%, 64% and 95%; and under Scheme C to be 21%, 46% and 61%. There was some improvement in rural and urban districts in Scheme B and Scheme A, but on the whole this was very slight.

In some areas it was found that the factors at the centres of towns were distinctly higher than at the outskirts. In Chesterfield, for example, there was a marked difference, but in Kirkcaldy there was not much difference.

Communal Buildings. The Survey of communal buildings, that is buildings other than private houses which could be used as shelters, was begun in November last year. There were buildings such as theatres, churches, schools, office blocks, department stores and so on, which could accommodate large numbers of people. This work is not complete, but some interesting results have already been received.

XV DR. McAULAY gave a review of progress in Radioactive Decontamination. He said:

It is three years since we last reviewed the problems of radiological decontamination. Of the few papers which have come in the first is one from the Chemical Defence Experimental Establishment - PTP (R) 20, which gives an account of their experiments on Decontamination of Skin and Clothing. There are two American papers that you might like to study at your leisure. One of them is a paper by the staff of the Stanford Research Institute under contract to the Office of Civil and Defense Mobilisation - CD 11727 - entitled 'Systems Analysis of Radiological Defence'. The other one is a report on 'Operation Plumbbob' - American Atomic Energy Commission - CD 11605. There are two other papers that I want to refer to - one is the very voluminous report on The Radiological Recovery of Fixed Military Installations, which seems to be based on questionably high effectiveness in cleaning up surfaces. The chart shows the residual number, i.e. the activity remaining after decontamination. We are rather doubtful about all these figures and particularly about 95% clean up of a concrete road by fire-hosing. The other report is by Technical Operations Incorporated - Radiological Defence Planning Guide. This particular group was asked to produce a complete defence plan for O.C.D.M., but their work is based on the same data which appear to relate entirely to large particles from bursts on desert sand, and easy to remove by simply blowing or washing them away.

Coming to the problem of the removal of contamination from skin, clothing, vehicles or equipment, this is a secondary problem because it is difficult to imagine conditions where the radioactive dust hazard could be serious without simultaneous lethal gamma exposure. In spite of high standards of personal cleanliness you may later get a Beta burn, but it is still only a burn. The main object of decontamination of skin and clothing is to keep the Operating Theatre clean and to keep contamination from getting into wounds or into food and drink. The first problem that Porton faced was to get a suitable simulant for fall-out. They produced a simulant consisting of glass microspheres impregnated with 0.15% Ta and these were irradiated in a pile to roughly .1 mc/gm. The microspheres were 10 to 100 microns in size which is the biggest they can make. The 10 micron particle represents something much more difficult to remove from skin and clothing than the kind of particle Mr. Stanbury was talking about, i.e. fall-out particles of 75 microns and above.

Then they had the problem of getting live skin, which was difficult, so they made a skin replica by taking an epoxy resin cast and from this they obtained a positive using a solution of methyl nylon in chloroform and alcohol. The replica gave a good representation of the mechanical surface of human skin. Porton found that with particles of 10 to 100 microns, by using ordinary soap and water, they could get effectively over 98% removal. In the case of clothing contaminated with these glass microspheres they found brushing or shaking ones jacket is not a very effective way of removing these particles - less than 60% in some cases - so they tried washing with detergents. I cannot imagine anyone doing this with a suit, but with washable fabrics over 98% was removed in this way. The fabrics were placed in the tub or in a washing machine and stirred about 100 times. In the case of outer clothing they naturally felt this was not desirable so they tried vacuum cleaning and got more than 98% removal.

Before going on to the question of decontamination of areas, there is one very important piece of real factual evidence I wish to mention. If a particle say of earth - 200 microns - is sucked up into the cloud, and fission products condense on it, and if that particle gets wet coming down, the activity after about 10 minutes becomes, to a large extent, fixed in the particle. Also, if the particle comes down on to a wet surface, and is wet for 10 minutes, the amount of transfer is likely to be negligible. Except for water bursts our problem is going to be very largely a mechanical one of removing the particles from the contaminated surface.

Now area decontamination. Here we are faced with the problem of a heavily contaminated built-up area, and what to do after 48 hours. We have to decide for instance, whether it is going to be worth while to clean up

roads, pavements, roofs etc. and when we ought to do the jobs. We have not got very clear answers to this problem in spite of the voluminous reports from America. The experimental work in the U.K. is being done by Porton who have recently acquired a road sweeper and various other items of equipment needed to clean up an area. They will carry out trials as soon as supplies of suitable simulant are available.

Let me go back to two years ago. Many of you probably read the Report of the Physics Lecturers Course. There I reviewed the problem and the many factors involved on which we have no accurate data. A number of factors were combined into one Parameter:-

$$N = \frac{PX T(25)}{2L}$$

where P is the resident population, X in feet per hour is the rate of clean up of a street, L the total street length to be cleaned, and T(25) the time in hours the operators could work before getting a dose of 25r. N represents the number of residents per operator required for decontamination. Thus if decontamination were started at 2, 4 or 6 days after the burst, the values of N would range from 185 to 370, from 500 to 900, and from 800 to 1,500. Now I assumed in doing the decontaminating that people came from outside to operate the road-sweeping equipment. Just before that, one person in each house came out for not more than half an hour and brushed all the contamination from the pavement and sidepaths into the street gutter. Following on the road sweepers which swept the fall-out into the street gutters, a water tank and pump enabled the contamination to be washed along the gutter and down the drain. It is interesting to note that in one of the American Operational Research reports the range of effort covered is one operator per 100 of the population up to one per thousand. The U.S. report - Radiological Recovery of Fixed Military Installations - gives some figures about rates of cleaning up. They assumed motorised flushing equipment, graders which scrape the earth into a windrow pile and leave it at the side, scrapers which lift up this windrow and put it into a container so that it can be moved and dumped somewhere else. They used bull-dozers, ploughs, and so on. They give the rate for fire hosing a street as 6,000 gallons per hour at 80 p.s.i. through each of two 1½ inch hoses and four men to each hose, or 7,500 sq. ft. per hour per hose. In the case of motorised equipment, i.e. the water flushing machine with two very powerful nozzles in front - this delivered 50,000 gallons per hour at 90 p.s.i. employing two men and decontaminating some 35,000 sq. ft. per hour. In the Plumbob report the calculations were something of the same order - an unpaved area of 500 ft. X 500 ft. = 250,000 sq. ft., was decontaminated in three hours or 80,000 sq. ft. clean up per hour. In my case I estimated the rate of street cleaning with a road sweeper and firehosing at between 40,000 and 150,000 sq. ft. per hour, assuming that contamination is washed down into street drains.

Now let me come to the Stanford Research Institute's study. They worked out what is called a 'methodology' for assessing the value of a decontamination procedure. Unfortunately they used a complicated basis of assessment, first a 'performance' value which is the rate of coverage multiplied by the fractional reduction of radiation divided by the exposure factor. From this they worked out a 'decontamination' value, which is the performance value multiplied by the fraction of open field radiation penetrating a shelter divided by above-ground area per capita. The results work out very much in the same range as we calculated. Two cases are assumed (a) 1 operator per 100 of the population, and (2) 1 operator per 1,000 of the population. The bulk of the effort is done by mechanised equipment but the population are expected to do a bit of spade work on unpaved areas. In the paper they give very interesting data on the distribution of certain types of surface in American towns and the proportion of certain classes of people likely to be available and useful for undertaking the decontamination. Assuming one operator per hundred of the population, a 50% dose rate reduction could be achieved if each member of the crew worked two 10-hour shifts, and a 90% dose rate reduction if each worked twenty 10-hour shifts. In my assessment I took only 25r as the limit of exposure for people engaged on decontamination. I must now go back and do it again for a wartime emergency exposure of 75r if this is justified to enable the community to survive. I might add that this particular SRI report - if anybody is interested enough to read it - has a beautiful graph. It shows the cost of saving the United States of

America in relation to the actual cost of the protective decontamination programme, in terms of the surviving population.

It is interesting to note that in an average American town, per 1,000 inhabitants there are 0.7 Sanitary Department employees, one fireman, 2.9 highway department workers, 1.4 policemen. These with watchmen and cleaners make up 1.8% of the total population possibly able and available to do this job. They have also considered that in America, of course, all cars would have their tanks at least half full in emergency - that means something like 10 hours travelling at 25 miles an hour, so everybody could beat it out of the contaminated area for some 250 miles. Each would have to take his own food, and this is where the Stanford Institute's estimate stops. They say they can carry the operation no further because they do not know what would happen when the family food supplies ran out.

I would like now to refer to the extremely valuable factual report on Operation Plumbbob in 1957. The report is called the 'Evaluation of Countermeasure System Components and Operational Procedures', but I don't think one ought to let the title frighten us away from the value of the report. They built an underground magazine type shelter about 25 ft. in the middle by 48 ft. long, covered with 3 ft. of earth, and they carried out a study of the dose rates during gamma flash and residual effects inside and outside the shelter to several days after the burst. It had large ventilators and one of the objects was to study the internal dose at various points inside in relation to the various apertures of the shelter. In the second part of the programme - three areas outside were selected as likely to receive fall-out. In one of the shots this particular shelter was almost a mile from Ground Zero. After the shot the fall-out built up over the shelter very rapidly - it started in about six minutes and it reached a maximum in 15 minutes from the burst. The maximum was 60 r.p.h., which is higher than they had budgeted for. It had been intended that a party should come out from the shelter to monitor the areas and to decontaminate one of the selected areas seven hours after the shot, but in an area at 60 r.p.h. at 15 minutes after burst, this was not possible until two days after and it presented a very valuable opportunity as the area was thoroughly monitored before and after decontamination and all personnel carried film badges. Three areas had been marked out, and at 7 hours after burst monitors were sent out to measure the dose rate at the centres of the three areas. One area which had a fairly high dose rate of 3 r.p.h. at 7 hours was selected. The area was a square of 500 ft. side. Two days after the burst four monitors went out and started at the centre and proceeded in steps to each corner, and the whole area was very thoroughly monitored at heights above the ground of 1 ft., 2 ft. and 3 ft. Another monitor went to various points outside and measured the dose rates so that we have a complete record of all relevant dose rates before, during and after the decontamination operation. The crews and their equipment consisting of four motor graders (pushing the earth to the side into windrows), two motorised scrapers, and one bull-dozer was kept three miles from G.Z. in a clear area. Decontamination was done in four stages and took three hours. In the first stage an area of 40 ft. X 40 ft. was cleared and then an additional 20 ft. round the periphery. This was then extended to 100 ft. X 100 ft. and finally to 500 ft. X 500 ft. The central area of 100 ft. X 100 ft. was monitored and rescraped in an attempt to get down to a residual number (R.N.) of 0.01, i.e. 99% dose rate reduction at the centre. However this was not achieved. The results at 3 ft. height were:-

<u>Area</u>	<u>R.N. at Centre (average)</u>
40ft. X 40ft.	0.39
60ft. X 60ft.	0.32
100ft. X 100ft.	0.24
500ft. X 500ft.	0.16

A second pass over the 100 ft. X 100 ft. area gave an R.N. of 0.11. The ground was rough and hard and a lot of boulders had to be removed which slowed them down very considerably.

wanting to go into the middle of a Z zone for the food there until considerably later, and it does lock on a first analysis as though his tasks will develop in a fairly orderly way.

BRIGADIER MULLINGTON: I see him starting fairly early. The Regional Food Controller will be edging round to see where he can get food from for areas badly hit.

DR. PURCELL: Well I quite agree with that, but I am equally convinced that his movements will be limited by the public control conditions and the gradual clearance of the zones. Could I ask you to continue to turn this problem over in your minds and let me have any considered opinions that you may have by correspondence; that is the best conclusion for this afternoon.

III

MR. STANBURY gave a talk on Study Torquemada, dealing with Fire Problems after a Megaton Explosion. He has provided the following summary:-

I. Estimation of initial fire incidence

The method used is based on that described in the Report of the Technical and Tactical Study Courses held at the Fire Service College in May, June and July 1952 entitled "The Fire Situation after an Atomic Attack on a British City" - a copy of which can be made available on application.

The British city concerned in these particular study courses was Birmingham and for this purpose a 1 in 12 scale model was made by the Birmingham Fire Brigade covering a 25° sector of the area likely to be affected by the explosion of a nominal atomic bomb over the centre of the city. With this model the problem of shielding - which is all important in this connection - could be dealt with quite satisfactorily. A lamp was set up at the point of burst in relation to the model, and it could be seen immediately which windows were exposed and which were shielded. After that it was only a question of estimating the chances of the development of continuing fires in relation to the fire risk and size of the fire compartment concerned by the methods described in detail in the report.

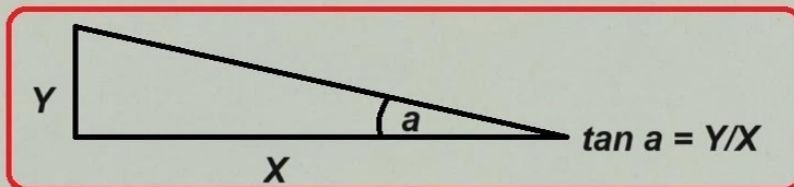
In this study we were concerned with the much larger area of damage produced by a 1 MT explosion, and we had no model. We are forced therefore to use maps and the most detailed maps available were the Insurance Plans of Liverpool and Birkenhead prepared by Messrs. C. E. Goad Ltd., which were hired specially for the purpose. These are to the scale of 40 ft. to the inch and they give complete details about road widths, height of buildings, construction etc. In order to reduce the volume and tediousness of the work involved in using maps the method developed for the Birmingham model had to be substantially simplified.

Effect of Shielding: Estimation of the Number of Exposed Floors

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height, then the number of exposed floors on the front of the buildings on the side of the road away from the explosion depends on

- (a) the angle of arrival of the rays, say α and
- (b) the width of the street = $10w$

Where w = number of units of 10 ft.



If we take the average depth of a floor to be 10 ft. then the number of exposed floors is given by

$$\tan \alpha = \frac{10n}{10w} \quad \text{or } n = w \tan \alpha$$

For a 1 MT groundburst bomb the height of the top of the fireball above ground is about 0.72 miles. Because this distance is large compared with the height of most buildings, the exposed upper floors do actually see a large part of the fireball and not just the top of it, but in assuming that the radiation is just as intense from the top as from the middle we are probably overestimating the fire situation which will result.

On the above basis the following table gives the number of exposed upper floors (to the nearest $\frac{1}{2}$ floor) for a range of distances from the explosion and a range of street widths.

Hence at 5 miles from 1 megaton ground burst, only top windows are exposed

TABLE I

Distance from explosion miles	Angle of arrival α°	$\tan \alpha$	Width of street (units of 10 ft.)							
			2	3	4	5	6	7	8	
1	35	.72	1.5	2	3	3.5	4.5	5	6	
1 $\frac{1}{2}$	26	.48	1	1.5	2	2.5	3	3.5	4	
2	20	.36	.5	1	1.5	2	2	2.5	3	
3	13 $\frac{1}{2}$.24	.5	.5	1	1	1.5	1.5	2	
4	10	.18	.5	.5	.5	1	1	1.5	1.5	
5	8	.15	.5	.5	.5	.5	1	1	1	
6	7	.12	-	.5	.5	.5	.5	1	1	
7	6	.1	-	-	.5	.5	.5	.5	1	

It is obvious that for street widths greater than 80 ft. at close ranges (or for example where there is an open space in front of a building) it can be immediately assumed that all floors are exposed; since few buildings have more than 5 or 6 floors. At the extreme range for ignition the angle of arrival varies so slowly that for street widths greater than 80 ft. the number of exposed floors can always be taken as one. It is for these reasons that the Table is stopped at 80 ft.

To the numbers obtained from Table I must be added or subtracted the differences in numbers of floors of opposing buildings as shown on the maps to give the actual number of exposed floors in any particular case. This number of course cannot be negative, nor greater than the total number of floors in the building exposed.

Variation with Range

In the Birmingham study an attempt was made to allow for the variation in intensity of the radiation, with distance from the explosion on the chance of ignition, but the foundation for this was not very sound. In this study it was assumed -

- (a) that there are no continuing fires inside a circle 1 mile in radius because of the complete collapse of all buildings
- (b) that out to 1 $\frac{1}{2}$ miles the only fires possible are those in buildings of steel framed or reinforced concrete construction
- (c) that the chance of ignition is 100% all the way from 1 $\frac{1}{2}$ miles to 5 miles, after which it drops to 30% for a further 2 miles.
 [At 7 miles from a 1 MT explosion the heat intensity is still 12 cal/sq.cm which is sufficient to ignite easily inflammable material like "Excelsior".]

Inclination of Streets to the Direct Line of the Heat Flash

The first two lines of the following table are taken from the Report already referred to.

TABLE II

Angle between heat flash and street (degrees)	90-75	75-60	60-45	45-30	30-15	15-0
Proportion of heat flash entering windows %	99	92.5	80	60	40	14
Proposed grouping for Torquemada	100%		80%		Nil	

For working with Goad Maps, the division into 6 angular groups is too cumbersome, and it was decided to use the 3 group system shown in the last line. This means that all streets inclined at an angle greater than 60° to the direction of the flash are assumed to be at right angles to it; all those between 30° and 60° have their chances of ignition reduced by 20%; and those below 30° are neglected. A small pilot study of one area showed that this approximation was very close, while the saving in work was considerable.

The chance of a continuing fire as affected by (a) Size of Fire Compartment and (b) Number of Windows.

This was dealt with in great detail in the earlier report, but considerable simplification was needed for use with the Goad maps.

The chance of a continuing fire developing from a small source of ignition decreases with the size of the fire compartment and increases with the number of sources of ignition i.e. with the number of exposed windows, and these were dealt with separately in the Birmingham model assessment. However, the decrease with size is roughly proportional to the area and the increase - because of windows - to the length (assuming an approximately square building). The overall effect is that the chance is inversely proportional to the length of the exposed front of the building.

In this study the chance has been still further reduced by two assumptions

- (a) that 25% of the windows have been whitewashed and
- (b) that 25% of the incipient fires are extinguished by fire guards giving an overall reduction of the chance of fire of 55% (75% x 75%).

Owing to the uncertainty connected with this part of the estimation there seemed to be no point in using more than 3 main fire compartment size groups and the figures finally adopted were as follows:-

Group (A)	20 ft. frontage.	Chance	0.2
Group (B)	40 ft. "	"	0.1
Group (C)	80 ft. "	"	0.05

In the streets inclined between 60° to 30° to the heat flash, these chances were reduced by 20% to

Group (A)	0.16
Group (B)	0.08
Group (C)	0.04

The Method of Estimation

The following routine method was adopted for making use of the principles enumerated above.

1. For any particular sheet of the Goad maps, the distance of the centre of the street to ground zero was first estimated to the nearest mile.
2. From the N/S pointer on the sheet, the direction of the flash was determined and the streets perpendicular to this (within 30°) were noted.
3. Starting from one end of each street, each exposed fire compartment was considered in turn and the number of exposed floors marked on a tracing paper overlay, using Table I together with the information on the numbers of floors of opposite buildings given on the map.
4. All the fire compartments in Group (A) were then noted and the number of exposed floors for each was multiplied by the chance of a continuing fire developing (0.2 in this case) and the number recorded on the overlay in Green. The fire compartments in Group (B) were dealt with in a similar way and the number recorded on the overlay in Yellow. Finally the fire compartments in Group (C) were dealt with, and the chances recorded on the overlay in Red.
5. This process was repeated for the buildings in the streets inclined between 60° to 30° to the flash, but using the appropriately reduced chance figures.
6. All the figures in each of the colour groups were then added to give the total chance that continuing fires would be started on any one floor of any one building for each group of fire compartment sizes. Let us assume that these numbers are x, y and z. Then these numbers of fires were marked in on the overlay as red ticks, the actual choice of which building in each group being immaterial.

Inevitably there were many classes of buildings which did not respond readily to the above method of analysis, and each had to be considered on its merits, bringing into play as much wartime experience in this field as was available to the Branch.

Secondary fires

The problem of so-called "secondary" fires i.e. - those started as a result of disruption of some kind or another caused by the blast - was dealt with in great detail in a paper entitled "The Fire Risk from Blast Damage" which also appeared in the Fire Service College Report already referred to. This was based on a careful study of all the fly bomb records. It was found that about 6% of the bombs were responsible for large continuing fires and about 40% for small fires in debris most of which went out of their own accord. If we assume that one tenth of the small fires continue the overall figure for continuing fires is 10%. In a groundburst 20 KT bomb, the damage produced is equivalent to that of about 1,250 fly bombs. For a 1 MT groundburst the number would be -

$$1,250 \left(\frac{10^3}{20} \right)^{2/3} = 50,000$$

and if 10% of these cause fires, there will be 5,000 secondary fires.

It is not expected that this type of fire would occur beyond six miles since this is the limit of damage. Thus secondary fires might occur on the average at a ~~density~~ ^{density} of $\frac{5000}{\pi 6^2} = 40/\text{sq. mile}$.

Each Goad Map covers an area of approximately 1/40th sq. mile so that on each map one extra fire must be included. Here again it is not important where fire is located, but it is reasonable to select a high fire risk occupancy such as paint ~~store~~, a furniture factory, or a garage.
store

II. Estimation of Fire Spread

In the area of Liverpool and Birkenhead covered by the Goad Maps, the numbers of fires at H + 1 turned out to be as follows:-

<u>Fire Compartment Size</u>	<u>Number</u>
Small	1050
Medium	223
Large	20
	<hr/>
	1293
Secondary fires allocated in roughly the same proportion	180
	<hr/>
	1473
	<hr/> <hr/>

The area not covered by the Goad Maps was largely residential so that most of these additional fires were in the small compartment category.

The total number of fires was between 7,000 and 8,000, and it was decided to allocate the following round numbers to each category:-

Small (S)	7,000
Medium (M)	500
Large (L)	50
	<hr/>
Total (N)	7,550
	<hr/> <hr/>

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs; thus the assumptions adopted must allow for the final destruction by fire of about 15,000 buildings which is about 1 in 10 to 1 in 15 of all the buildings in the area.

For the purpose of assessing possible spread let us assume -

Proportion of fires in each category which burn out without spreading = p_1

Proportion of fires which spread to one other building = p_2

" " " " " " two " buildings = p_3

" " " " " " three " " = p_4

In each category $p_1 + p_2 + p_3 + p_4 = 1$ and the final number of buildings destroyed by fire =

$$S(p_1 + 2p_2 + 3p_3 + 4p_4)s + M(p_1 + 2p_2 + 3p_3 + 4p_4)m + L(p_1 + 2p_2 + 3p_3 + 4p_4)l$$

As a first shot the following numbers are suggested:-

	Fire Compartment Size		
	Small	Medium	Large
p_1	.6	.25	.1
p_2	.2	.25	.2
p_3	.1	.25	.3
p_4	.1	.25	.4

This gives:-

Final number of buildings destroyed by fire = $(7,000 \times 1.7) + (500 \times 2.5) + (50 \times 3.0) = 13,300$ which is near enough for this purpose.

In order to estimate the number of fires burning at any given time it was necessary to make further assumptions about

- (a) burn-out times and
- (b) starting times for first, second and third spread fires.

The following are suggested:-

	Fire Compartment Size		
	Small	Medium	Large
Burn-out time from ignition (hours)	$1\frac{3}{4}$	$3\frac{1}{2}$	7
Starting time for			
1st-spread fires	$H + 1\frac{1}{2}$	$H + 1\frac{1}{2}$	$H + 1\frac{1}{2}$
2nd- " "	$H + 3$	$H + 3$	$H + 3$
3rd- " "	$H + 4\frac{1}{2}$	$H + 4\frac{1}{2}$	$H + 4\frac{1}{2}$

These two sets of assumptions, combined with the actual numbers of fires in each category were then used to calculate the fire position at various times after H + 1 as follows:-

Time After Burst (hours)	Origination of Fire	Fire Compartment Size		
		Small	Medium	Large
H + 1	Initial heat flash + secondary fires	7,000	500	50
H + 2	Initial fires	Nil	500	50
	1st spread fires (p2 + p3 + p4)	2,800	375	45
	2nd " " (p3 + p4)	Nil	2,800	Nil
	3rd " " (p4)	Nil	Nil	Nil
H + 4	Initial fires	Nil	Nil	50
	1st spread fires (p2 + p3 + p4)	Nil	375	45
	2nd " " (p3 + p4)	1,400	250	35
	3rd " " (p4)	Nil	Nil	Nil
H + 8	Initial fires	Nil	Nil	Nil
	1st spread fires (p2 + p3 + p4)	Nil	Nil	45
	2nd " " (p3 + p4)	Nil	Nil	35
	3rd " " (p4)	Nil	125	20

These numbers were divided between the various fire areas in the Liverpool-Bootle district using the H + 1 assessment as the basis. The local fire officers with their special experience of the fire risks in their areas, allocated the positions and determined where the fire spread was most likely to take place. This work, which was most painstakingly carried out resulted in the production of the four fire situation maps which you see here displayed.

XIX DR. PURCELL: I should like to say how much we have appreciated the help of the Scientific Advisers during the past year. Additionally I know that you will not wish to close without allowing me to say to the Commandant of the Staff College how much we appreciate the kindness and hospitality that we have received during this Conference. We particularly appreciate his magical touch with the weather; the sun always shines when we come here. Thank you very much indeed.

$B = 1.24 (1 - e^{-g})$ radians

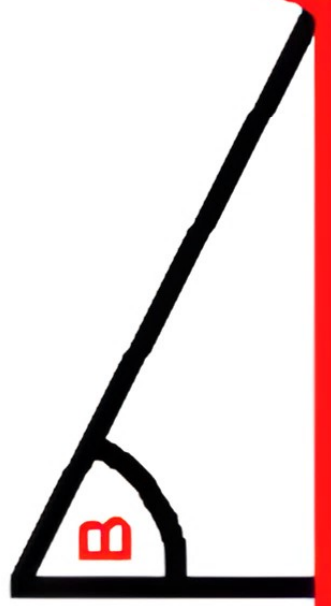
$g = 0.4 (t/T)^{2.4}$

t = time

T = time when reflected shock reaches bottom of fireball, flattening it into a truncated sphere

(Maximum allowed value of $B = 71$ degrees)

Volume of truncated sphere shaped fireball equals the volume of a spherical fireball at the same time after burst



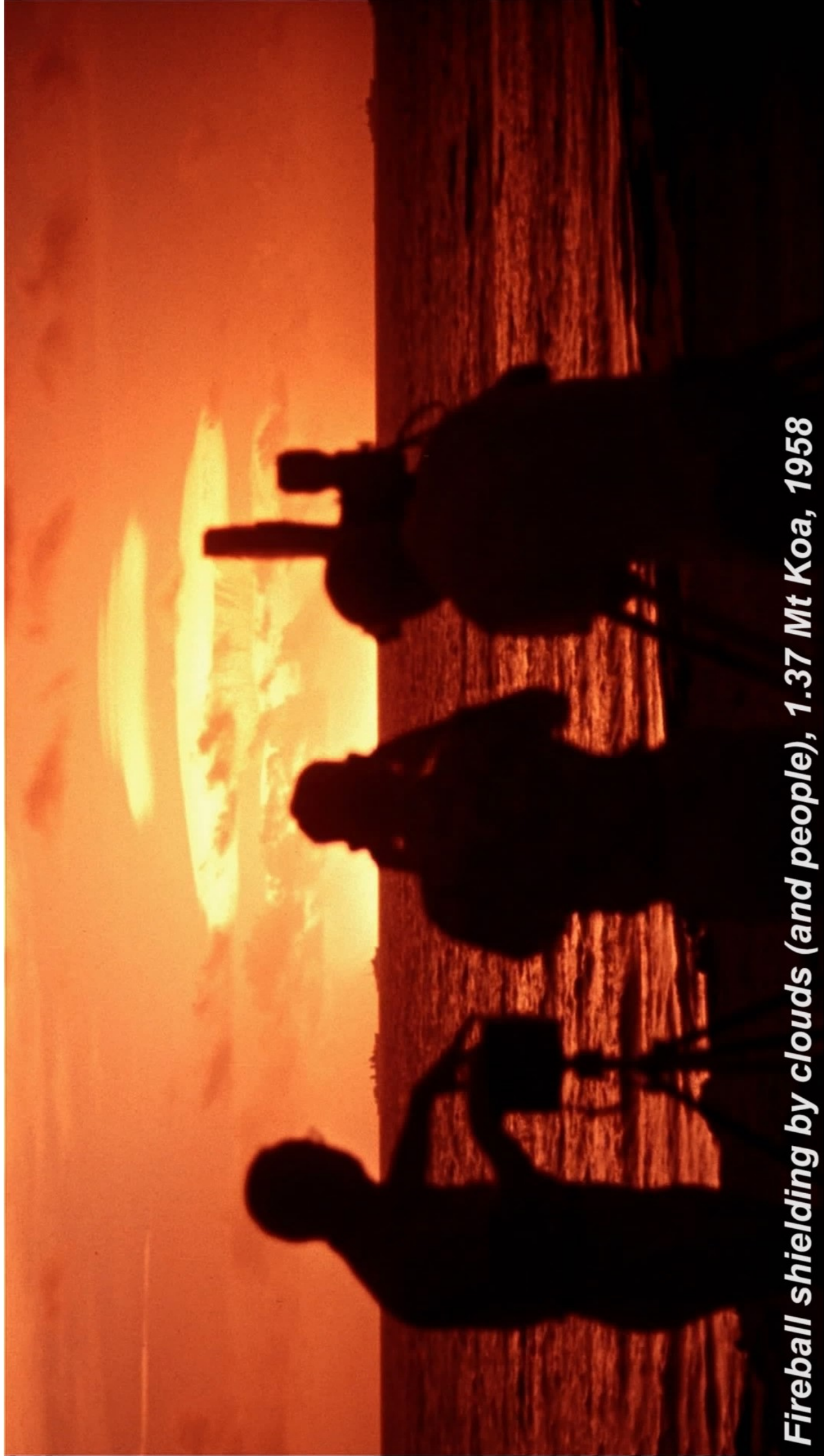
John R. Keith and Anthony F. Portare, An Analysis of Army Thermal Transmissivity Calculations, Kaman Sciences Corp., Arlington, VA., report DNA-TR-84-388 (1984)

**Top of fireball is cooled by water entrainment;
bottom is blocked by city skyline (or clouds) duh**

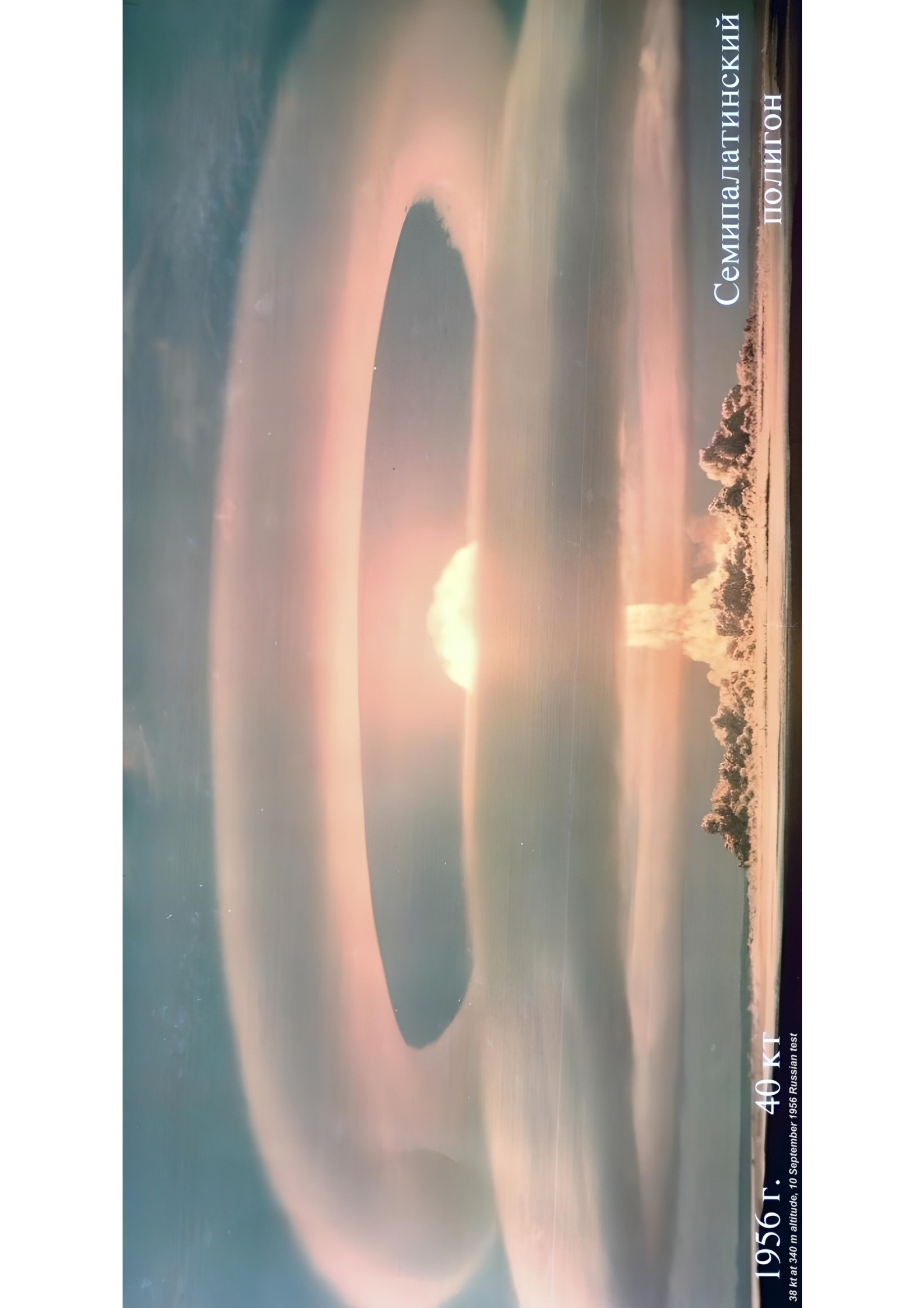


NORMAL CLOUDS

**BRAVO (15 megatons or 22 megatons) seen not
from an aircraft above cloud cover, but from
surface level: clouds block hot base of fireball!**



Fireball shielding by clouds (and people), 1.37 Mt Koa, 1958



1956 г. 40 кт

38 kt at 340 m altitude, 10 September 1956 Russian test

Семипалатинский

ПОЛИГОН



BUFFALO-1: Severe damage to Supermarine Swift



Operation Antler, Maralinga, 1957.

Air Ministry
AP 3362

RESTRICTED

The information given in this document is not to be communicated, either directly or indirectly, to the Press or to any person not authorized to receive it

WO
CODE NO.
9612

26/GS Trg Publications/2427



**AN INTRODUCTION
TO
NUCLEAR WEAPON
EFFECTS
1959**

Promulgated by Command of the Army Council,
E. W. Playfair

Promulgated by Command of the Air Council,
W. J. Bean

Crown Copyright Reserved

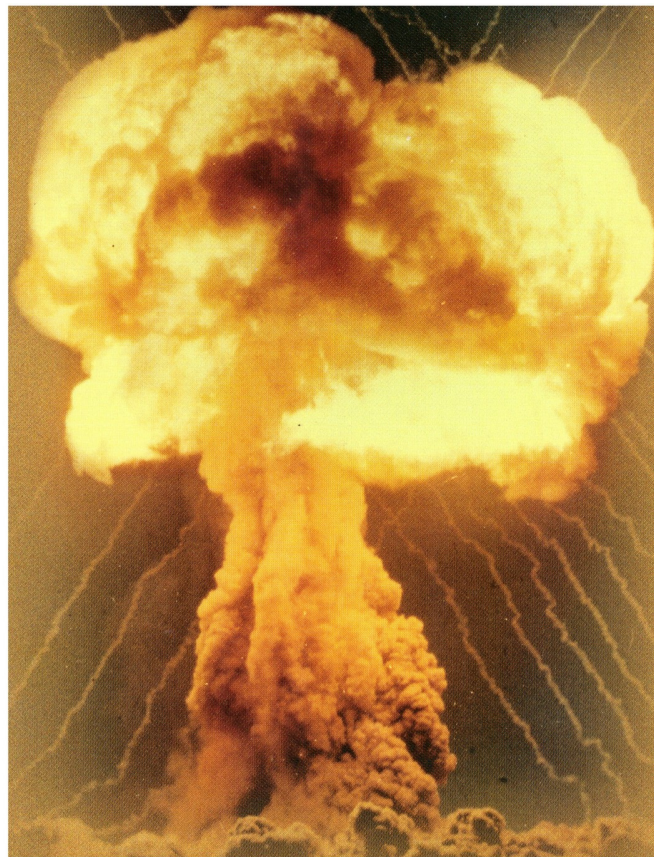
TABLE II.—Target response table for military equipment and personnel (for 20 KT and 1 KT weapon)

Equipment	Approximate peak Overpressure (psi) (Taken from 20KT near surface burst results)	Equivalent scaled psi for a 1 KT	Damage level to be expected
Heavy tanks	55	85	Moderate
Scout cars	30	50	Severe
B vehicles	20	28	Moderate
.. .. .	12	17	Light
.. .. .	15	21	Severe
.. .. .	10	14	Moderate
.. .. .	7	10	Light
Field artillery (in open)	20	28	Severe
.. .. .	15	21	Moderate
.. .. .	10	14	Light
Field artillery (in gun pit)	20	28	Light
Heavy mortars	40	75	Moderate
.. .. .	15	21	Light
Heavy girder bridges (side on)	20	28	Severe
Wireless sets	15	21	Severe
.. .. .	10	14	Moderate
.. .. .	3	4	Moderate
4 men fire position—			
LMG embrasure and shelter	30	50	Severe
.. .. .	18	27	Moderate
.. .. .	8	13	Light
Main trench	30	50	Severe
Aircraft parked—			
Bomber	5±2	7±2	Depending on aspect
Fighter	12	17	Severe
Aircraft airborne	10±5	14±7	Kill
Men (but remember other accompanying effects)			
			Injury level to be expected
Men standing in open	8	13	Severe
.. .. .	4	7	Moderate
.. .. .	3	4	Light
Men laying in open	12	17	Severe
.. .. .	9	14	Moderate
.. .. .	6	8	Light
Men in revetted trenches	20	28	Moderate
.. .. .	8	13	Light

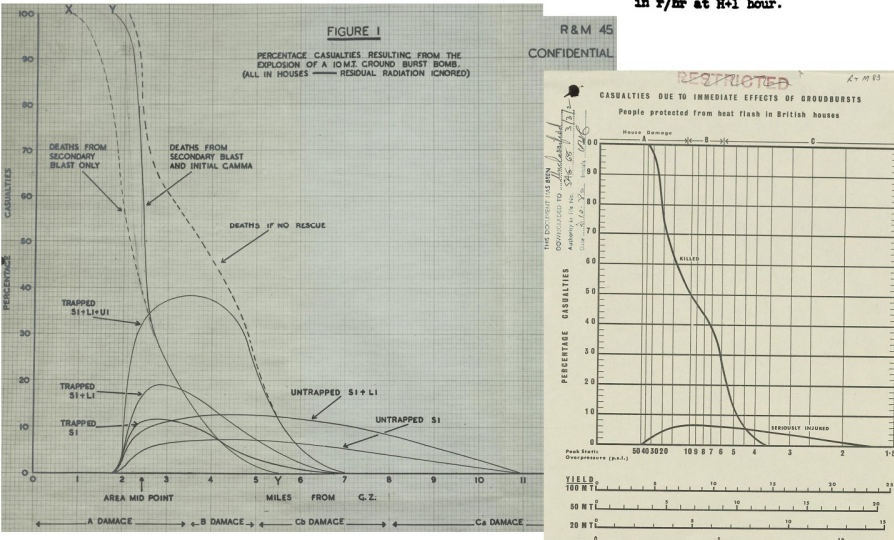
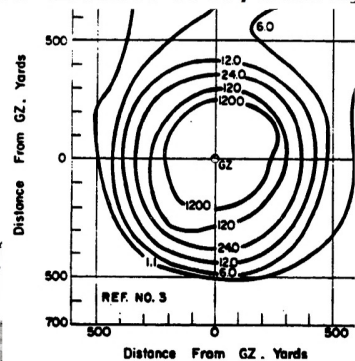
Damage level criteria for equipment

1. *Light damage*.—Will not interfere seriously with immediate use. Will require some repair to restore to full use.
2. *Moderate damage*.—Requires repair facilities available in field workshops.
3. *Severe damage*.—Requires base repair.

1 For associated dynamic pressures, see Table III.
2 Normalized for non-desert terrain.



25 kt composite core (Pu239 within U235) tactical air burst on 9 October 1957, held by balloon at 300m



ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

AWRE-T1/54, 27 Aug. 1954

SECRET-GUARD

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE

(Monte Bello Islands, Australia—October, 1952)

$$p = \frac{130 \times 10^9}{R^3} + \frac{7.7 \times 10^6}{R^2} + \frac{13.5 \times 10^3}{R} \text{ p.s.i.}$$

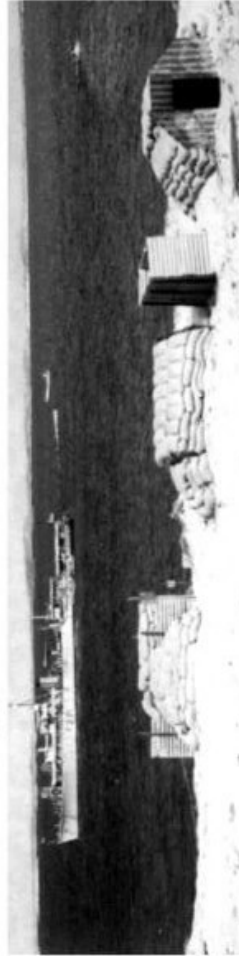


Fig. 12.1, Andersons at 1380 ft range from bomb ship shown in the photo, moored 400 yards off shore.



Left: Fig. 12.3, Andersons at 1800 ft after burst. Right: Fig. 12.4, Andersons protected by blast walls at 2760 ft.

12.1. Blast Damage to Anderson Shelters

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

At 2,760 feet, Fig. 12.4, some of the sandbags covering the shelters were displaced and the blast walls were distorted whilst at 3,390 feet, Fig. 12.5, the effect was quite small. At these distances, the shelters were not in direct view of the explosion owing to intervening sandhills.

13. THE PENETRATION OF THE GAMMA FLASH

13.1. Experiments on the Protection from the Gamma Flash afforded by Slit Trenches

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

TABLE 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

Type of trench	Rectangular broadside-on open		Rectangular end-on open	Circular open		Rectangular broadside-on covered
	1,300	943		1,300	943	
Distance (yards) ...	1,300	943	733	1,300	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	3,000	14,000
Depth below ground level (inches)	150	1,000	—	230	1,200	—
...	75	430	—	150	545	(75)
...	33.3	150	584	60	188	47.6
...	23	70	216	31.6	86	25
...	(20)	43	100	20	48.5	13
...	—	—	61	13.6	10.7	7.7
...	—	—	(46.7)	(8.6)	(33.3)	5
...	—	—	—	—	—	(3.5)

Entries in brackets are extrapolations or estimates.

Fig. 86 Construction and installation drawings for outdoor kit shelter design.

1982 Anderson shelter

(Domestic Nuclear Shelters - Technical Guidance)

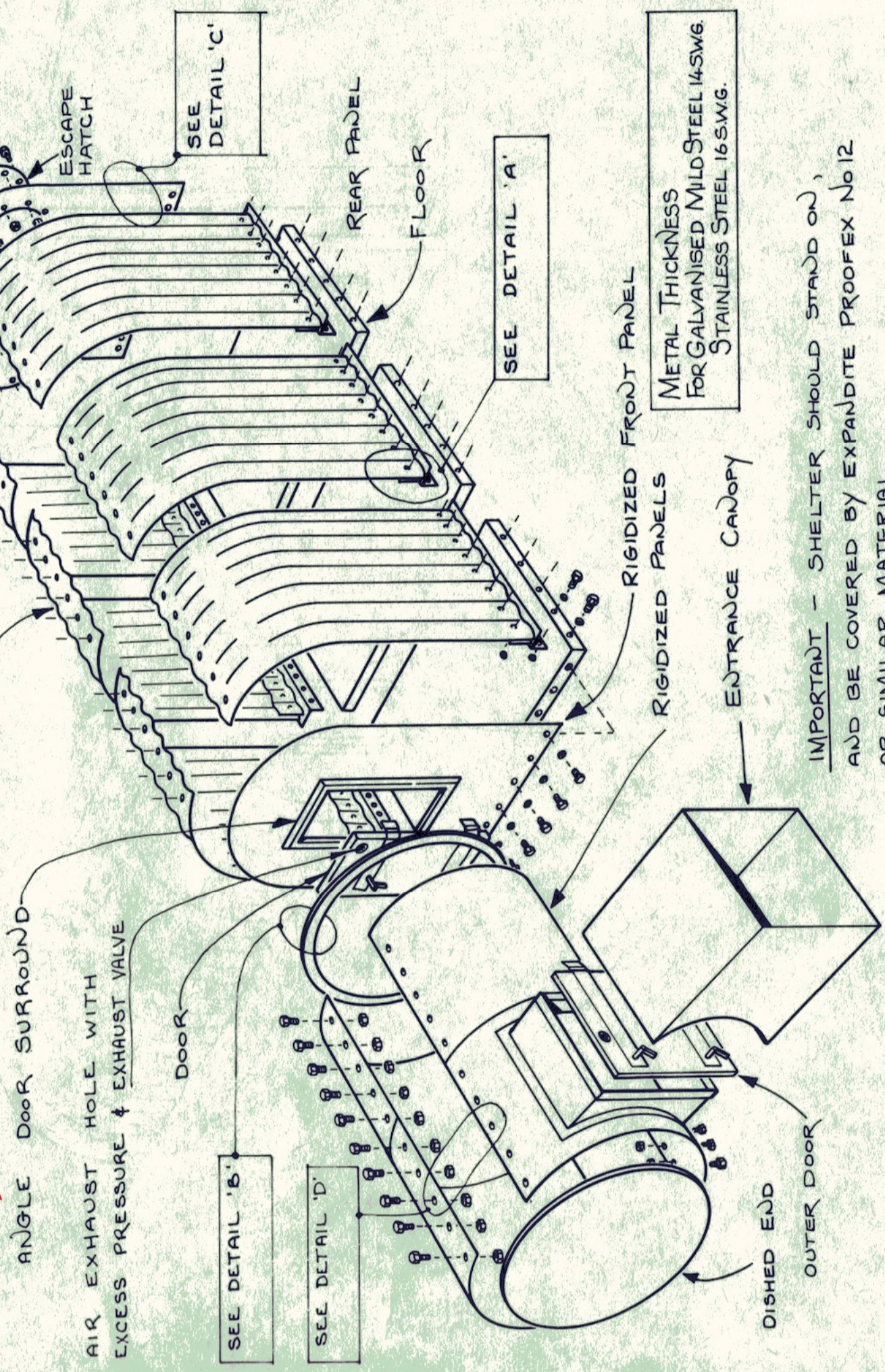


Fig. 92

UK Government 1982 Anderson

Concrete Slab 150m.m. thick with
One layer of mesh B.S. ref. A.142
placed centrally

1000 m.m. Minimum Earth Cover
Stiffen Surface with : Rockery or Grass / Roots
Stones or Concrete.

Polythene or Cloth layer.

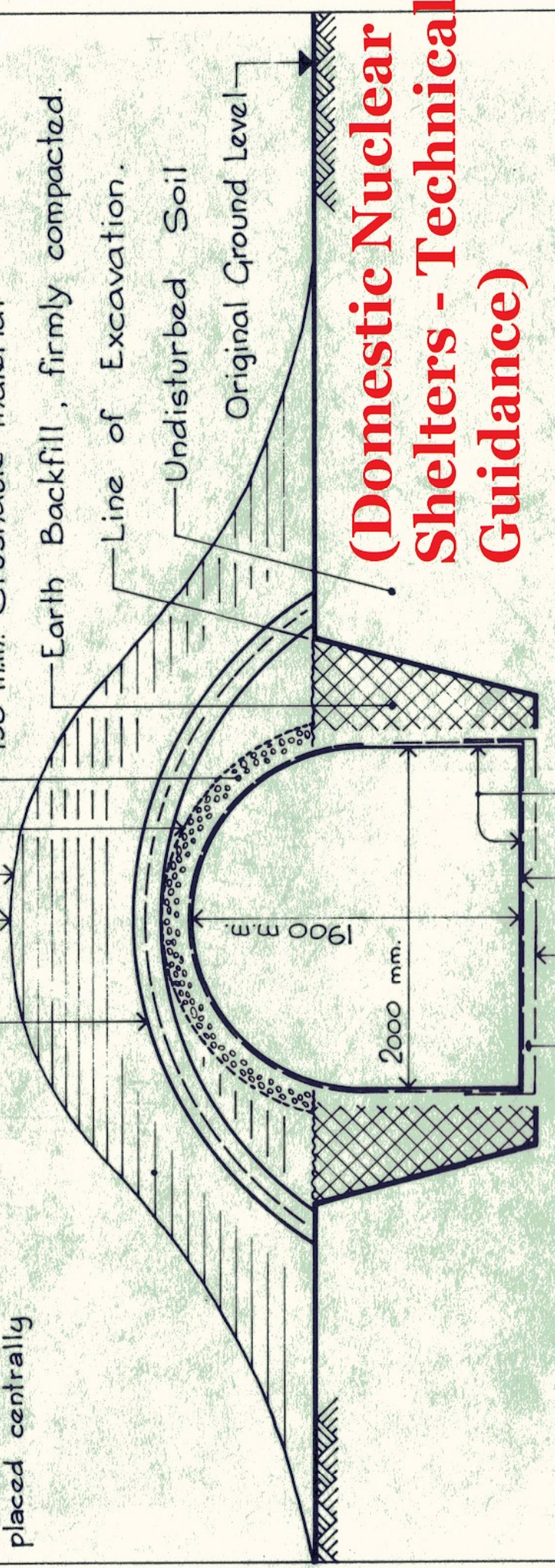
150 m.m. Crushable material

Earth Backfill, firmly compacted.

Line of Excavation.

Undisturbed Soil

Original Ground Level



(Domestic Nuclear Shelters - Technical Guidance)

20 m.m. Plywood Base Slab.

Line of Basic Shelter

'Proofex N° 12' or similar material

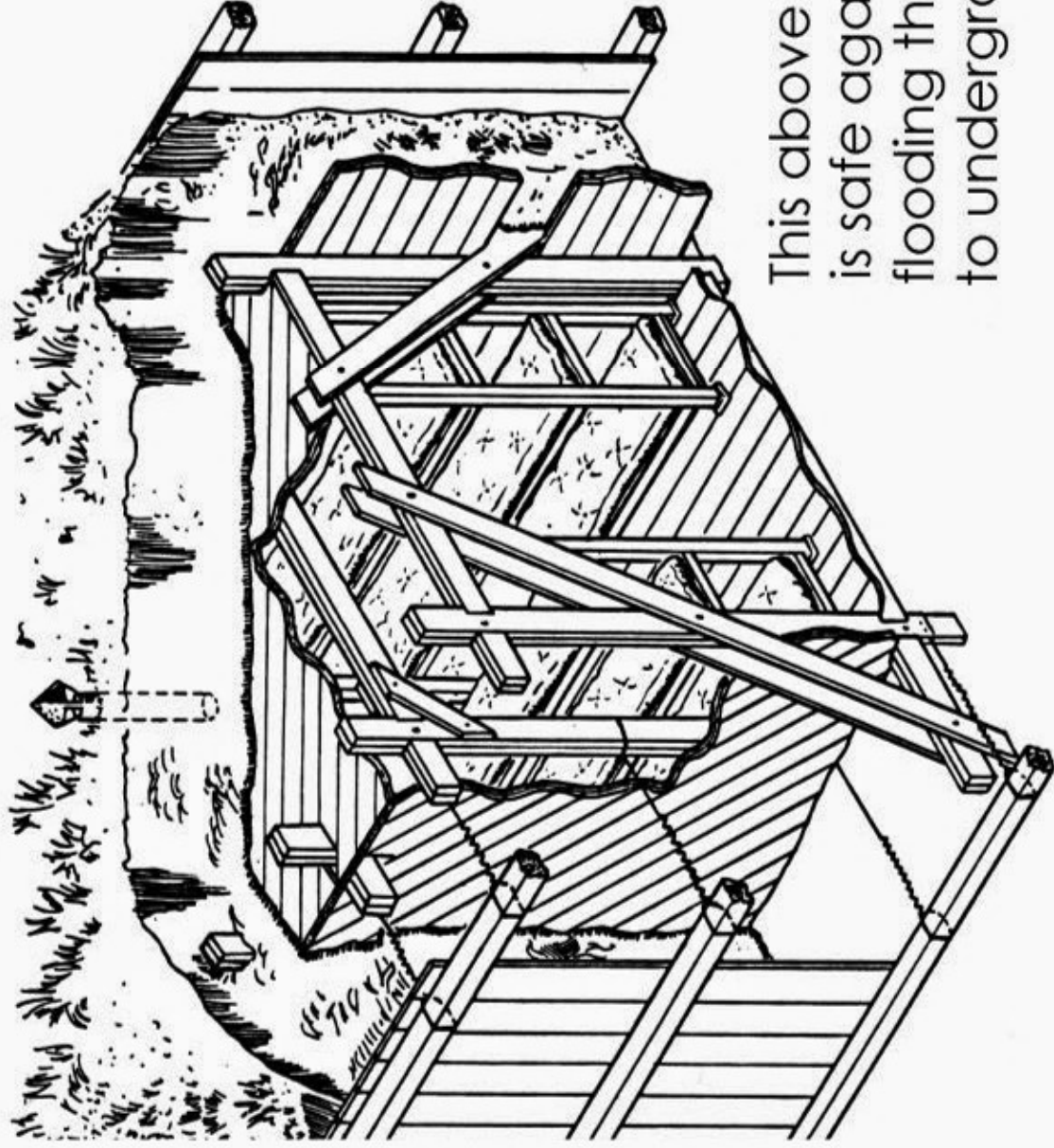
'Expandite Proofex N° 12.' or similar material

applied to bottom of plywood and
turned up to lap with shelter.

applied to the entire exterior of the shelter.

TYPICAL CROSS SECTION : (FLAT BOTTOM)

PROOF-TESTED OUTDOOR ABOVE GROUND WOOD AND EARTH SHELTER



No casualties
in test at 20 ft
(250 kg TNT)
(Minor damage
to shelter from
the crater debris)

This above ground shelter
is safe against ground water
flooding that occurs in winter
to underground shelter/trench.

UK Home Office Research and Experiments Department Bulletin C26,
*Timber shelters for countries where timber is plentiful and steel difficult
to obtain, April 1942. This is a surface (not underground) wooden shelter
with 2.5 ft earth fills in the gap between two wooden walls, and on roof.*

**FROM: "Royal Observer Corps Journal",
Feb. 1985, page 26**

FRAGMENTS

Feb. '85:

UK Home Office "Fission
FRAGMENTS" article, reprinted in
ROC Journal V27n2

PROTECTION AGAINST RADIATION A. L. Mather ex-SA, Northumberland

In 'Protect and Survive' a recommendation is made on page 11 para. 2 'Use tables if they are large enough to provide you all with shelter. Surround them and cover them with heavy furniture filled with sand, earth, books or clothing'. Similar shelters are proposed in paras 1 and 3.

Apart from the fact that under certain circumstances of location and weather sufficient soil may not be available, none of the materials suggested for radiation protection is of use to the shelter-bound occupants. The use of survival supplies as a radiation barrier is to be recommended, if not, indeed considered essential. As previously suggested fuel supplies, which have a half value thickness approaching that of soil, could be used in this way. Food supplies should be stacked in boxes as the inner protective barrier together with immediate water supplies. Water has a half value thickness of 200mm compared with 140mm for earth. One therefore has only to create a water barrier 50% greater in width to equate with a soil barrier. The water barrier can be erected in a very short time merely by filling suitable containers by means of a hosepipe. In this way an adequate shelter can be made in a fraction of the time needed for the filling and transportation of sandbags. Further this would provide a strategic supply of water for fire fighting, drinking, washing and for the later survival period during which water supplies may be limited.

Cheap containers would be needed for such a barrier and dustbins, plastic bottles etc would be expensive and inconvenient to store when not required. There is, however, a suitable container made by Bowater Scott Ltd (and possibly by other companies) which is used for the conveyance of milk. These are double walled plastic bags of five gallon capacity with screw caps. The bags are supplied flat together with fold flat heavy duty cardboard boxes. When the box is erected and the plastic bag within is filled, it takes the shape of the box and forms a fairly rigid 'brick' of water of dimensions 25 cm x 24 cm x 42 cm. These bricks may be stacked to a height of 4 units (on

their side) without bursting or collapsing. The bags are very strong and access may be made to them by cutting a sealed plastic tube which is attached to the screw top. Additives would be required to prevent the growth of algae or bacteria.

Not only can one stack these water bricks above and around the shelter but these could also be put on upper and attic floors to improve radiation protection in the fall out room. It would also improve fire protection in the upper floor of the building. The cost of these bags is low (£592 per 1000 including cardboard box). Doubling the thickness of the box to improve stacking properties would increase the cost of the box by 50%. No doubt the price could be improved by simplification of design and by mass production.

One weakness of such a system is the susceptibility of the water bags to rupture by blast damage. Those bags exposed to windows or openings should be protected by a suitable tough barrier such as carpets, heavy timber and/or doors.

There would be load limitations on some types of floor and this aspect would need to be discussed with builders before installation. However as the half thickness for water is larger than that for soil then the equivalent weight of water would be spread over a larger area of the floor.

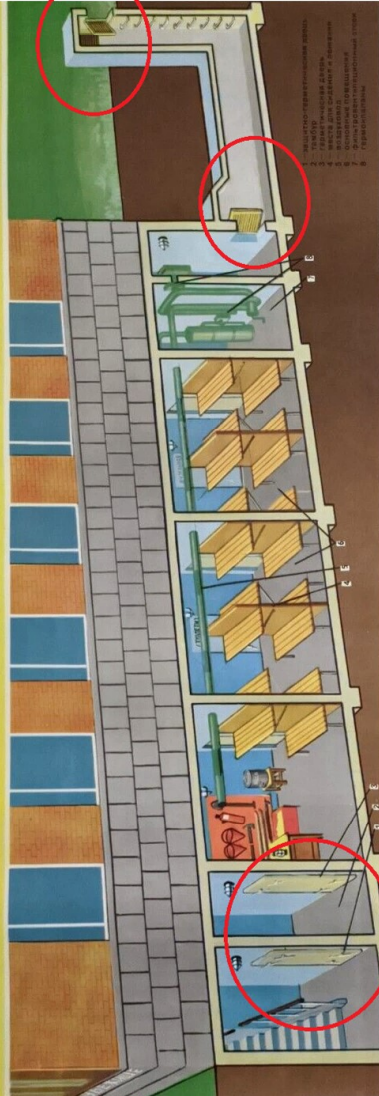
The progressive reduction of radiation being received by the shelter will allow the progressive use of water from the radiation barrier. The empty water bags may be used to store waste liquids.

This system would perhaps find its primary application to indoor shelters but there is no reason why water may not be used to supplement barriers in other types of shelter. The containers in collapsed form are compact and may be stored in lofts or sheds. In an emergency the barrier may be erected and filled by a hosepipe in a very short period of time without any great effort. This would be of considerable help to elderly or infirm people and, in fact, to most people with only a short time to construct a shelter.

ОБЩЕЕ УСТРОЙСТВО УБЕЖИЩА

УБЕЖИЩА ЗАЩИЩАЮТ ЛЮДЕЙ ОТ ВОЗДЕЙСТВИЯ ЯДЕРНОГО ОРУЖИЯ, ОТРАВЛЯЮЩИХ ВЕЩЕСТВ И БАКТЕРИАЛЬНЫХ СРЕДСТВ

ВНУТРЕННЕЕ ОБОРУДОВАНИЕ ВСТРОЕННОГО УБЕЖИЩА



ABOVE: DOUBLE BLAST PRESSURE DOORS

По сигналу «Воздушная тревога» и убежища (участие) с оповещением о начале воздушной тревоги, «Воздушная тревога», «Воздушная тревога», «Воздушная тревога» и «Воздушная тревога».

Места для сидения устанавливаются в рядах по 6-8 и 0,50х1,8 м. Количество мест для сидения должно быть в 1,5 раза больше количества людей, которые будут размещаться в убежище (включая детей).

Основные помещения строятся из расчета 1,5 м³ объема и 0,5 м² площади на одного укрываемого человека.

РАЗМЕЩЕНИЕ ЛЮДЕЙ В УБЕЖИЩЕ



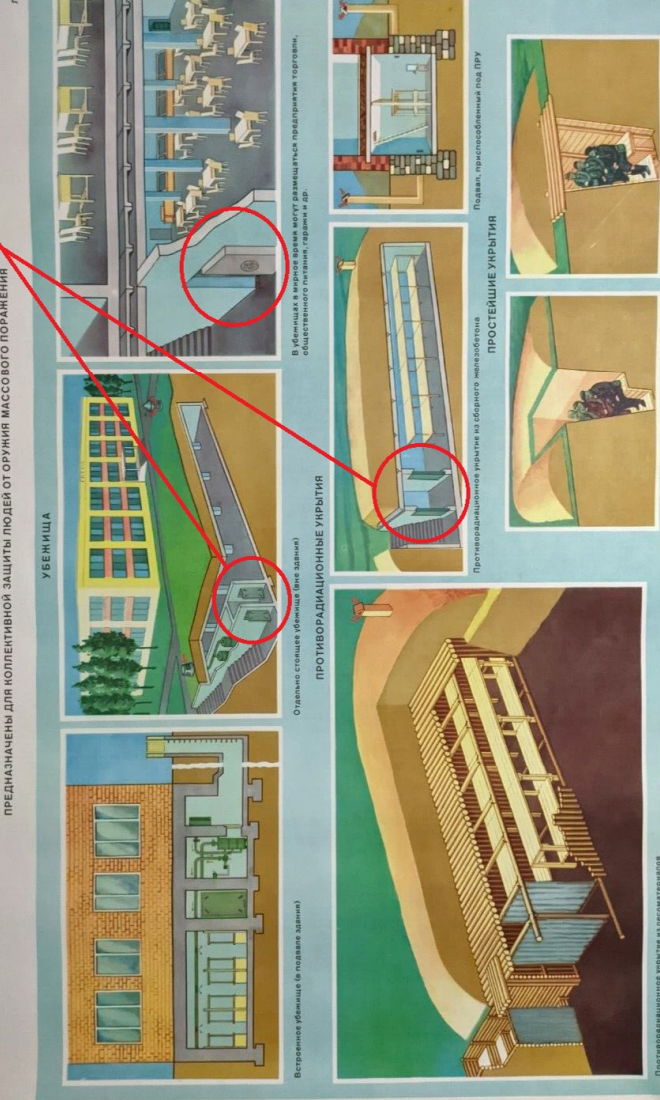
exit/air vent
of basement
shelter



RUSSIAN CIVIL DEFENSE POSTERS
SHOWING DOUBLE BLAST PRESSURE
DOORS AT MAIN AND ALSO EMERGENCY
EXITS, INDICATING VERY HARD NUCLEAR
TEST PROVEN SHELTERS DESIGNS

ЗАЩИТНЫЕ СООРУЖЕНИЯ ГРАЖДАНСКОЙ ОБОРОНЫ

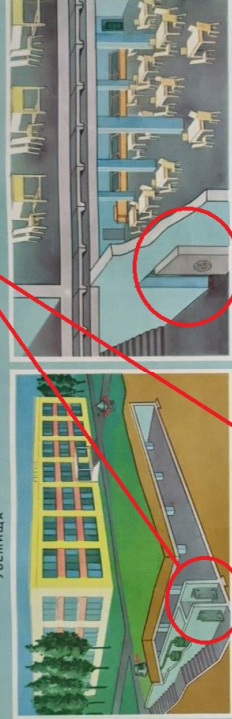
ПРЕДНАЗНАЧЕНЫ ДЛЯ КОЛЛЕКТИВНОЙ ЗАЩИТЫ ЛЮДЕЙ ОТ ОРУЖИЯ МАССОВОГО ПОРАЖЕНИЯ



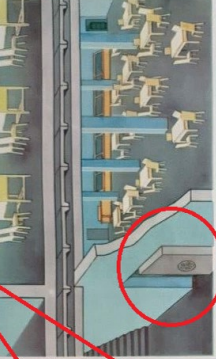
DOUBLE BLAST PRESSURE DOORS

ПРИМЕРЫ ЗАЩИТНЫХ СООРУЖЕНИЙ

УБЕЖИЩА

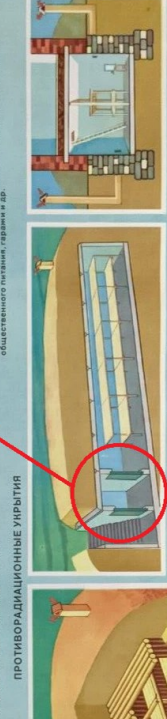


Встрепенное убежище (в подвале здания)

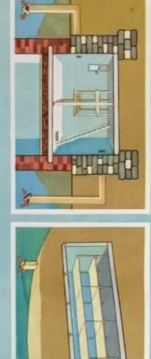


В убежище устанавливаются двери с двойным взрывоударным давлением

Противорадиационные укрытия



Огнестойкое убежище (на здании)



Противорадиационное укрытие из сборного железобетона

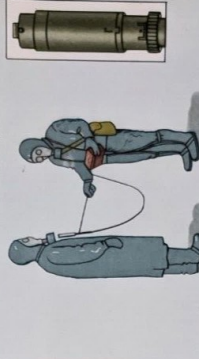


Полки, приспособленные под ПРУ



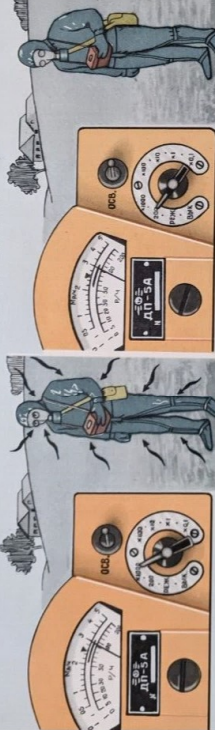
Примеры защиты

ИЗМЕРЕНИЕ РАДИОАКТИВНОЙ ЗАРАЖЕННОСТИ ОДЕЖДЫ



Измерение проводят по верхней шнурке при положении прибора в положении "1" (X10³) и "X1000". Главная шкала имеет деления "1", "10", "100" и "1000". Деления на расстоянии 1-15 см.

ИЗМЕРЕНИЕ УРОВНЯ РАДИАЦИИ НА МЕСТНОСТИ

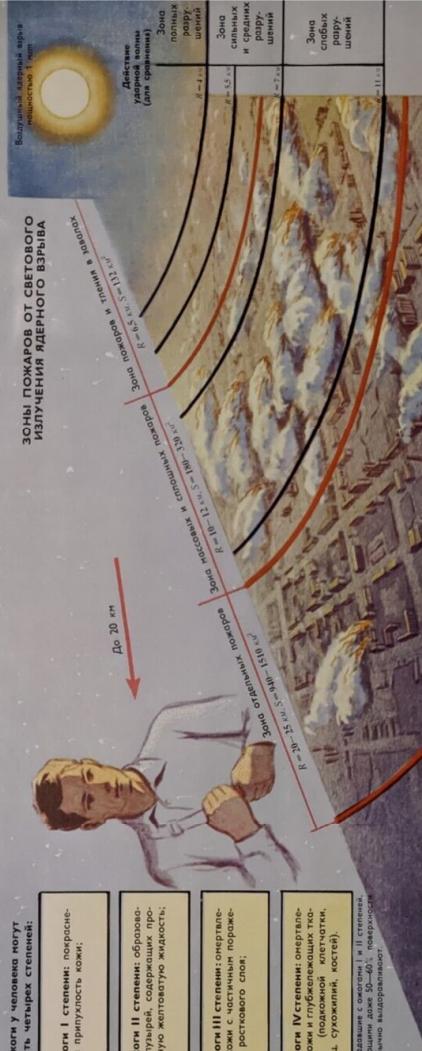


Измерение уровня радиации до 5 мкР проводится по верхней шкале при положении переключателя в положении "X10³" и "X10⁴". При данном положении переключателя и положении стрелки прибора уровень радиации 3 мкР.

При уровнях радиации более 5 мкР измерение проводится по нижней шкале при положении переключателя в положении "X10³" и "X10⁴". При данном положении переключателя и положении стрелки прибора уровень радиации 100 мкР.

ПОРАЖАЮЩЕЕ ДЕЙСТВИЕ СВЕТОВОГО ИЗЛУЧЕНИЯ

СВЕТОВОЕ ИЗЛУЧЕНИЕ ВЫЗЫВАЕТ У ЧЕЛОВЕКА ОЖОГИ НЕЗАЩИЩЕННЫХ УЧАСТКОВ КОЖИ, ВРЕМЕННОЕ ИЛИ ПОЛНОЕ ОСЛЕПЛЕНИЕ, ВОЗГОРАНИЕ ОДЕЖДЫ И ДРУГИХ ОБЪЕКТОВ, ВОЗНИКНОВЕНИЕ ПОЖАРОВ И ОГНЕВЫХ ШТОРМОВ



Ожоги у человека могут быть четырех степеней:

Ожоги I степени: покраснение и припухлость кожи;

Ожоги II степени: образование пузырей, содержащих прозрачную желтоватую жидкость;

Ожоги III степени: омертвление тканей, образование пузырей розоватого цвета;

Ожоги IV степени: омертвление тканей (подожой клетчатки, мышц, сухожилий, костей).

Поражения I степени в 100 метрах достигают даже 50-60% поверхности кожи, обычно индуратируются.

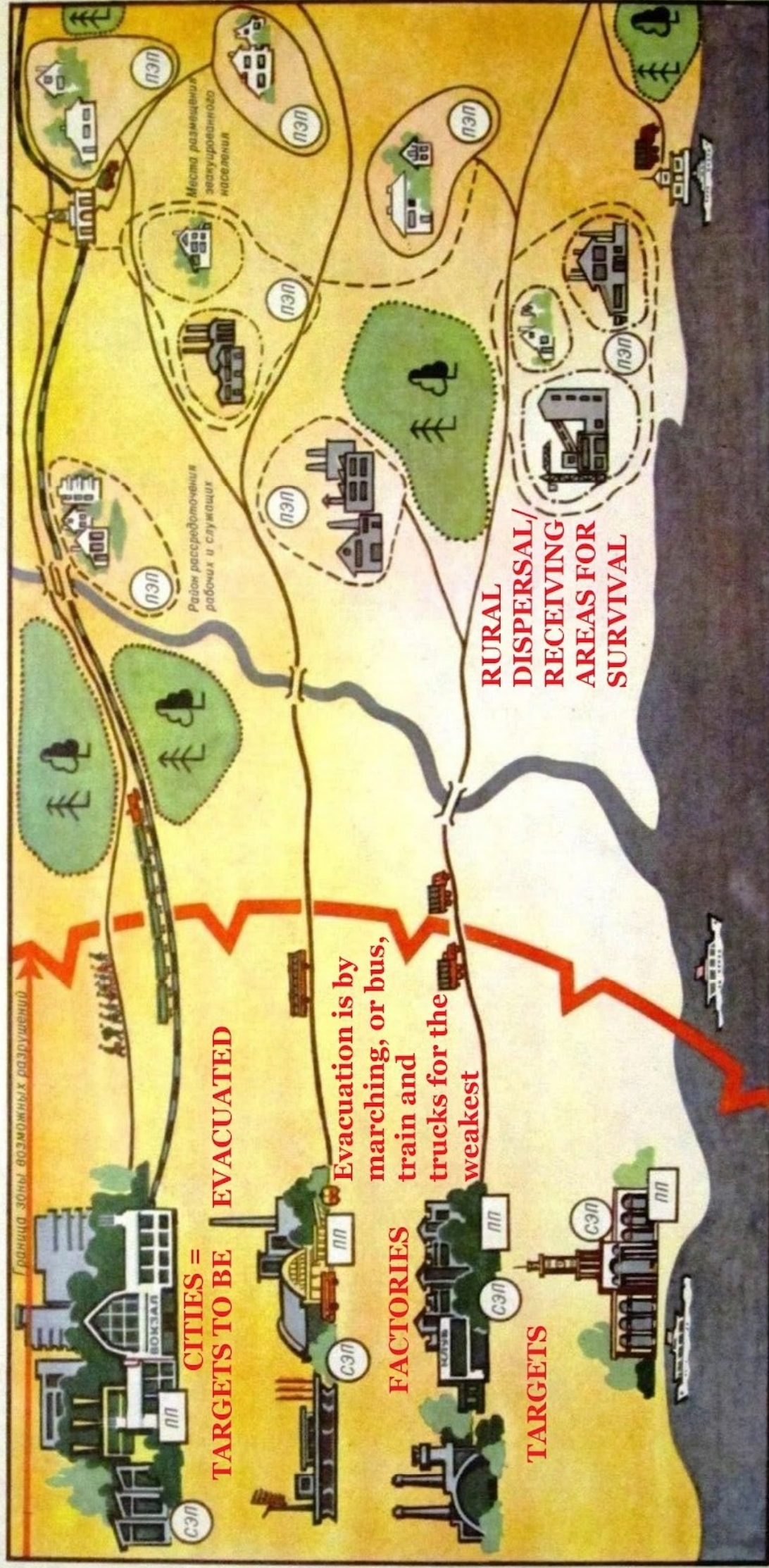
ЗОНА ПОЖАРОВ ОТ СВЕТОВОГО ИЗЛУЧЕНИЯ ЯДЕРНОГО ВЗРЫВА

Дистанция от эпицентра (для справки)	Зона полных разрывов деревьев	Зона сильных разрывов деревьев	Зона слабых разрывов деревьев
R = 1,5	R = 1,5	R = 1,5	R = 1,5
R = 2,5	R = 2,5	R = 2,5	R = 2,5
R = 5,0	R = 5,0	R = 5,0	R = 5,0
R = 10,0	R = 10,0	R = 10,0	R = 10,0
R = 20,0	R = 20,0	R = 20,0	R = 20,0
R = 50,0	R = 50,0	R = 50,0	R = 50,0
R = 100,0	R = 100,0	R = 100,0	R = 100,0
R = 200,0	R = 200,0	R = 200,0	R = 200,0
R = 500,0	R = 500,0	R = 500,0	R = 500,0
R = 1000,0	R = 1000,0	R = 1000,0	R = 1000,0

= Evacuation and dispersal of the population

РАССРЕДОТОЧЕНИЕ И ЭВАКУАЦИЯ — ЭТО ОРГАНИЗОВАННЫЙ ВЫВОД И ВЫВОЗ НАСЕЛЕНИЯ ИЗ ГОРОДОВ И РАЗМЕЩЕНИЕ ЕГО В ЗАГОРОДНОЙ ЗОНЕ, ПРОВОДИМЫЕ В ПЕРИОД УГРОЗЫ НАПАДЕНИЯ ПРОТИВНИКА, С ЦЕЛЬЮ СНИЖЕНИЯ ПОТЕРЬ СРЕДИ НАСЕЛЕНИЯ В СЛУЧАЕ ПРИМЕНЕНИЯ ПРОТИВНИКОМ ОРУЖИЯ МАССОВОГО ПОРАЖЕНИЯ. РАССРЕДОТОЧЕНИЕ И ЭВАКУАЦИЯ ПРОВОДЯТСЯ В КРАТЧАЙШИЕ СРОКИ КОМБИНИРОВАННЫМ СПОСОБОМ С ИСПОЛЬЗОВАНИЕМ ВСЕХ ВИДОВ

ТРАНСПОРТА, НЕ ЗАНЯТОГО ВОЕННЫМИ И НЕОТЛОЖНЫМИ ПРОИЗВОДСТВЕННЫМИ И ХОЗЯЙСТВЕННЫМИ ПЕРЕВОЗКАМИ. РАССРЕДОТОЧЕНИЕ И ЭВАКУАЦИЯ РАБОЧИХ, СЛУЖАЩИХ И ЧЛЕНОВ ИХ СЕМЕЙ ОСУЩЕСТВЛЯЕТСЯ ПО ПРОИЗВОДСТВЕННОМУ ПРИНЦИПУ. ЭВАКУАЦИЯ НАСЕЛЕНИЯ, НЕ ЗАНЯТОГО НА ПРОИЗВОДСТВЕ, ОСУЩЕСТВЛЯЕТСЯ ПО ТЕРРИТОРИАЛЬНОМУ ПРИНЦИПУ (ПО МЕСТУ ЖИТЕЛЬСТВА) ДОМОУПРАВЛЕНИЯМИ И ЖИЛИЩНО-ЭКСПЛУАТАЦИОННЫМИ КОНТОРАМИ. ДЕТИ ОБЫЧНО ЭВАКУИРУЮТСЯ ВМЕСТЕ С РОДИТЕЛЯМИ.



СОКРАЩЕНИЯ НА СХЕМЕ:

СЭП — сборный эвакуационный пункт; ПЭП — приемный эвакуационный пункт; ПП — пункт посадки

ШЕЛТЕРС IN CITIES ARE USED FOR THEM

KEY WORKERS ARE NOT EVACUATED (HARD



5 Megaton airburst; at 8000 feet high, fireball does not touch ground; there is no significant fall-out. Underground trains undamaged

Masonry bridges intact at 1.7 miles; steam locomotives head on to blast at 2½ miles still run. Man, if protected from heat and debris, can live at 2 miles

G.P.O. tower cores stand at 2½ miles; new Civil Defence aerials can easily be fitted. Ships at 2½ miles damaged but seaworthy

Outer edge of rubble 3¼ miles. Houses 75 per cent. down at 5¼ miles; but 90 per cent. of people under stairs will live

Factory chimneys survive at 3½ miles, heavy lathes and major industrial plant at 6 miles

Truss bridges usable at 4½ miles, diesel locomotives dented but will run at 5½ miles

Electricity pylons, self-supporting radio transmitting towers and cars survive at about 6 miles

The whole subject of nuclear war is so nasty that most people prefer not to think about it at all. If they are forced to, they probably have two hazy but permanent convictions: a couple of H bombs will completely flatten the country, and that Civil Defence quite rightly lay down and died years ago. Neither idea is accurate. For the second, Civil Defence in its wider

aspects is very much alive; spending this year will amount to £19.5 million, and we are well up the international league table of the amount spent per head of the population.

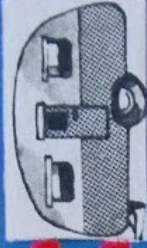
- W. Germany 17s. 6d.
- Britain 10s. 0d.
- Italy 5s. 0d.
- U.S.A. 4s. 6d.
- Sweden 2s. 4d.
- France 2s. 0d.

Since 1948, when C.D. began, we

have spent over £1000 million; roughly the capital cost of the deterrent and delivery systems.

As for the H bomb, terrifying though it is because of the loss of life it will cause, it is not as totally destructive as is popularly supposed. This diagram, based on information gathered at Hiroshima, Nagasaki and in American weapons trials, shows how close various objects can be to a five megaton airburst and survive.

We show the effects of an airburst because that is the most efficient way of using a nuclear weapon against a city. Blast carries 30 per cent. further, heat 60 per cent. further than from a ground burst. There would be no significant fall-out, but anyone launching a large-scale attack might well be glad of that, since it has been calculated by W. J. Humphries of the United States Weather Bureau that the dust thrown into the stratosphere by a 2000 mega-



Limit of major fire zone in average British weather

Scale: each band represents one mile

70 per cent. of trees still stand at 10 miles

Caravans dented but can be made habitable at 13 miles

Tiles and glass damaged in ordinary houses at 13 miles, but can be repaired. Telephone wires still up. Outer limit of fires and first-degree burns

tons groundburst would reduce solar radiation by 20 per cent. and might precipitate another ice-age.

The strong tactical point about nuclear weapons is their ability to raise fires. It's often thought these will coalesce into firestorms - as shown in *The War Game*. There is some doubt whether this will happen: but since one can't do much about a firestorm except to build deep shelters - which we can't afford - the point is rather academic.

So much for the relative certainties of the single bomb. If we were involved in an all-out war more than one would arrive. How many, and where? The basic problem is to imagine an enemy's motives in launching a strike against this country, but the Home Office makes the underlying assumption that a bomb might arrive anywhere (in C.D. exercises they often fall on the most unlikely places) mixed in with two basic attack patterns. One, the pre-

emptive counter strike, imagines a hail of perhaps 100 one megaton warheads directed at naval bases, military headquarters and the V bombers' dispersal fields. But as Bomber Command claim they can scramble their aircraft and have them safely on their way within the four-minute warning period, it is arguable that an enemy might prefer to deal with them more cheaply during their run in over his territory.

The other attack pattern is a coun-

ter city strike. The best H bomb targets are dense masses of houses and people: Britain is unfortunately well provided. We are the third most densely populated country in the world, with 550 people to the square mile: half of us live in cities of 100,000 or more. With unlimited rockets and warheads, one could kill everybody in these islands. But against this one must set our share of an enemy's stockpile. There are several rather arbitrary ways →

SECRET

This document consists of 2 pages
No. 1 of 1 Copies, Series 1

RADIATION DOSES PERTINENT
TO LITTLE FELLER I
(NUCLEAR TACTICAL EXERCISE)

ASSUMPTIONS:

0.02 kt nuclear



b. Effective wind of 15 knots.

Total Infinity Doses (RAD)

Range (Meters)	Residual		Initial Neutron		Initial Gamma		Cloud Transit		Total	
	No Protection	Fox-hole	No Protection	Fox-hole	No Protection	Fox-hole	No Protection	Fox-hole	No Protection	Fox-hole
200	600	60	2000	600	280	28	27	14	2907	702
400	60	6	180	54	44	4.4	9	4.5	293	69
600	15	1.5	40	12	10	1	5	2.5	70	17
800	6	.6	10	3	4	.4	3	1.5	23	5.5
1000	3	.3	3.5	1	1.5	.15	2	1.0	10	3.0
1200	1.5	.15	.5	.15	1.0	.1	1	.5	4	.9
1500	.7	.07	-	-	-	-	.6	.3	1.5	.4
2000	.3	.03	-	-	-	-	.5	.3	1	.3

- NOTES:
1. Fission products assumed to arrive at very early times.
 2. Cloud transit dose based on integration under similar shaped curve at all distances--error not significant for this purpose--source HARDTACK WT-1602.
 3. Table provides doses for most serious downwind case line and total dose assumes cloud transit directly down that line.
 4. Following transmission factors are applied for the Foxhole case:
 - a. Residual - .1
 - b. Initial Neutron - .3
 - c. Initial Gamma - .1
 - d. Transit Cloud - .5 (Based on collimation by foxhole and orientation of soldier with respect to source. This is probably conservative.)

DASA 64458

SECRET

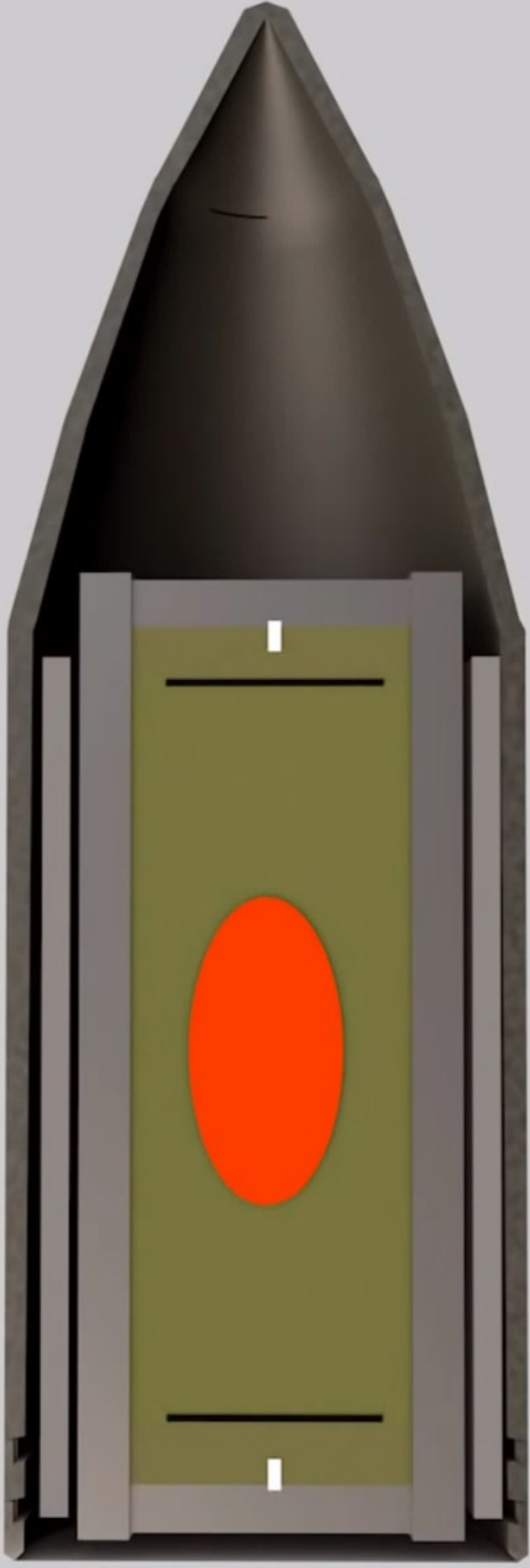
RESTRICTED DATA
ATOMIC ENERGY ACT 1954

JFKNSF-301a-001
-p0086

SANITIZED
E.O. 13526, SEC. 3.5
NLK-09-126
By Mr. NARA, Date 12/10

Incl # 2 (4)

W-48





HANDBOOK OF NUCLEAR WEAPON EFFECTS

Interactive CD

ELECTRONIC
VERSION 3
NOVEMBER 6, 2002



A product of the Defense Threat Reduction Agency (DTRA)

Distribution authorized to U.S. Government agencies and their contractors; Critical Technology, September 1996. Other requests for this document shall be referred to the Defense Threat Reduction Agency, 8725 John J. Kingman Rd., Ft. Belvoir, VA 22060-6021.

Warning-This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Section 1772) or the Export Administration Act of 1979, as amended.

The document on this CD-ROM is readable with Adobe Acrobat Version 4.0 and higher. It is best operated on a PC platform using Windows 95/98/2000/ME/NT.

The equations can be accessed using Mathcad professional; information about this product is available at <http://www.mathsoft.com>. The downloadable Mathcad 8 engine is no longer offered by MathSoft. Use of this software does not

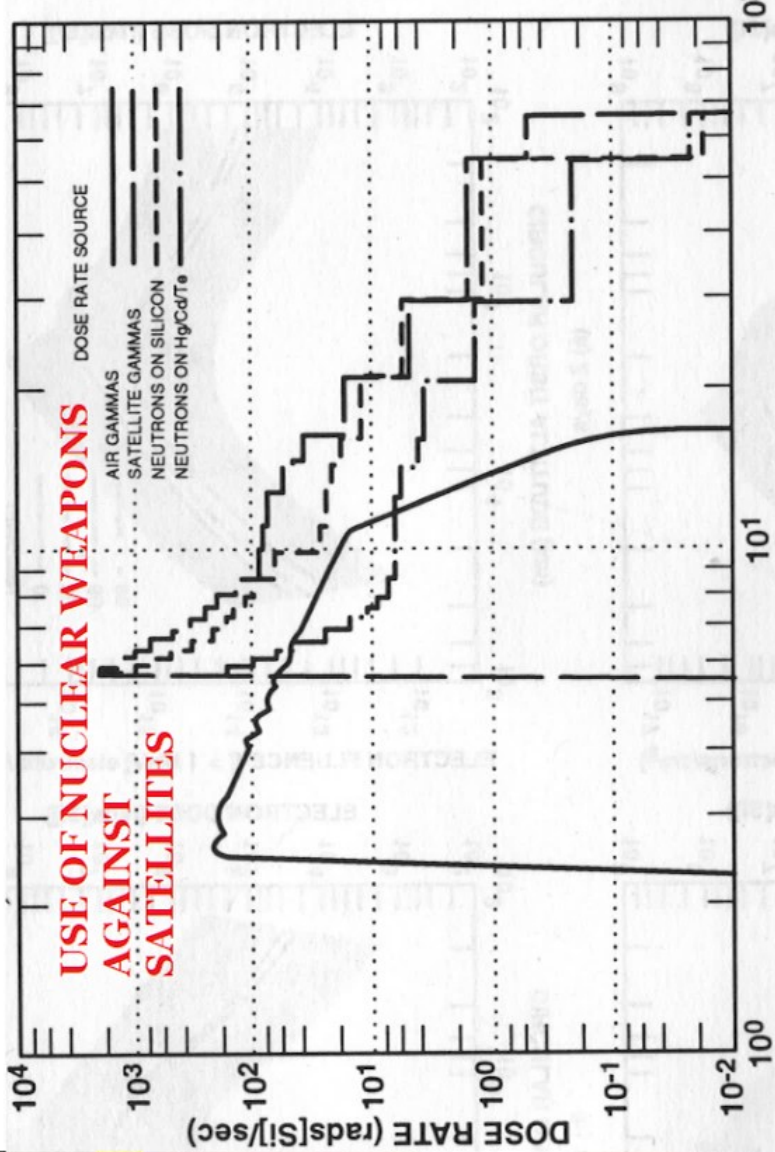


Figure 22.3. Neutron-Induced Dose Rate Versus Time for a 1-MT Detonation at 100 km HOB on a Satellite Located at 400 km Altitude (Burst Range, 300 km).

ANNEX B - TAILORED OUTPUTS OF WEAPONS

HOW CRITICAL IS THIS TO US CAPABILITIES OR WHAT LOSSES CAN WE STAND?

POSSIBLE LONG TERM TECHNOLOGICAL BREAKTHROUGHS

PROBABLE GAINS THROUGH CONTINUED TESTING UNDER I TBT

PRESENT STATUS

GAINS SINCE LTB TREATY

OBJECTIVE OF TESTING

WEAPON EFFECT

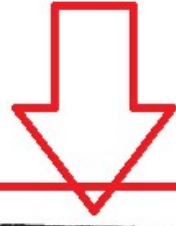
A. ENHANCEMENT AND SUPPRESSION OF EFFECTS

1. Gamma Rays

Increase the fraction of energy produced in a nuclear explosion which is emitted as gamma rays. Such a weapon would provide increased over present weapons in EMP effect and transient radiation effect on electronic systems. Potential applications in strategic areas, ballistic defense systems, and as source for understanding EMP generation and determining EMP and TREE effects.

Criticality of this is difficult to assess since EMP generation and effects are poorly understood. Development of these weapons is not critical to understanding EMP and TREE effects. Nuclear testing is required to develop these weapons and be assured of output.

EMP effect is enhanced by neutron bombs with chromium and nickel casing to convert neutron energy into gamma rays (1966 JCS Top Secret report)



ANNEX A - GENERAL IMPROVEMENTS OF NUCLEAR WEAPONS

AREA	OBJECTIVE OF TESTING	GAINS SINCE LTB TREATY	PRESENT STATUS	PROBABLE GAINS THROUGH CONTINUED TESTING UNDER LTBT	POSSIBLE LONG TERM TECHNOLOGICAL BREAKTHROUGHS	HOW CRITICAL IS THIS TO US CAPABILITIES OR WHAT LOSSES CAN WE STAND?
<p>EFFICIENCY (use of Pu 239, U235, T)</p>	<p>Reduce the amount of fissionable and fusionable material required to obtain the desired weapon performance. Savings in Pu 239 and T are particularly significant since they are not naturally occurring and must be produced by neutron bombardment in reactors.</p>	<p>(1) Development of all fusion weapons with minimum dependence on T.</p>	<p>1966 US Joint Chiefs of Staff Top Secret report calls for minimal T use as a long term aim.</p>	<p>E.g., isentropic compression of D+D fusion capsule within a Li6D shell!</p>	<p>(1) Efficiency of use of U235 does not appear to be critical problem since anticipated weapon requirements at least up through 1973 are well below production. Economic strength of US and availability of natural resources sufficient to improve production if necessary.</p> <p>(2) Efficiency of use of Pu and T could be important (based on present production estimates) if AEM systems small R/Vs using large quantities of reactor products are deployed in large numbers. Presently anticipated requirements are close to estimated production. However, more production is possible at great expense thru construction of more reactors.</p>	

CK2349562865-jcs-test-ban-1966

Атомный проект СССР

Документы и материалы

Под общей редакцией Л.Д. Рябева

Том III Водородная бомба 1945–1956

Книга 2

Составители:

Г.А. Гончаров (отв. составитель), П.П. Максименко



Наука • Fizmatlit



Москва — Саров
2009

№ 208

Отчет НИИ-1011 по обоснованию конструкции и расчетам изделия РДС-202

6 июня 1956 г.¹
Сов. секретно
(Особой важности)
Экз. № 1

RDS-202.
Note that this design was changed when tested with 50 Mt in 1961

Основные расчетные данные РДС-202
Зам. гл. конструктора Забобахин Е.И.
Начальник 1 сектора Романов Ю.А.

Введение

В настоящем отчете изложено обоснование конструкции РДС-202 и основные расчетные данные этого изделия.

В результате успешного завершения работ КБ-11 по РДС-37 и его испытания был окончательно проверен новый принцип конструирования изделий, позволяющий создавать изделия очень большой мощности с высоким КПД. Результаты всех работ по изделию РДС-37 показали, что на этом принципе могут быть созданы изделия с тротиловым эквивалентом в *десятки и даже сотни миллионов тонн*, а также позволили оценить необходимые для таких изделий количества активных веществ (главным образом Li^6D).

Эти выводы и оценки и послужили основанием для [выдачи] задания нашему институту на разработку нового изделия РДС-202, значительно превосходящего по мощности все изделия, испытанные до настоящего времени как в СССР, так и в США.

В задании на проектирование предусмотрена мощность изделия и количество Li^6D , которое может быть в нем израсходовано, а именно полный тротиловый эквивалент должен составить *20–30 млн т*, общее количество Li^6D (с (...) % содержанием изотопа Li^6) — до (...) тонн.

ENGLISH TRANSLATION:

№ 208

NII-1011 report on the justification of the design and calculations of the RDS-202 product

NOTE: This 6 June 1956 report states that they can produce up to about 38 Mt from a 25 ton bomb, using RDS-37 principles. The later revised design used the 1958 tested Trutnev "double approach" system, about 2.5 times more efficient.

Basic calculation data of RDS-202
Deputy Chief Designer Zababakhin E.I.
Head of Sector 1 Romanov Yu.A.
Introduction

This report outlines the rationale for the design of the RDS-202 and the basic design data of this product.

As a result of the successful completion of the work of KB-11 on RDS-37 and its testing, a new principle of product design was finally tested, which makes it possible to create products of very high power with high efficiency. The results of all work on the RDS-37 product showed that products with a TNT equivalent of tens or even hundreds of millions of tons can be created on this principle, and also allowed us to estimate the amounts of active substances necessary for such products (mainly Li^6D).

These conclusions and assessments served as the basis for [issuing] a task to our institute for the development of a new RDS-202 product, significantly exceeding in power all products tested to date both in the USSR and in the USA.

The design assignment provides for the capacity of the product and the amount of Li^6D that can be consumed in it, namely, the total TNT equivalent should be 20-30 million tons, the total amount of Li^6D (with (...) % content of the isotope Li^6) - up to (...) tons.

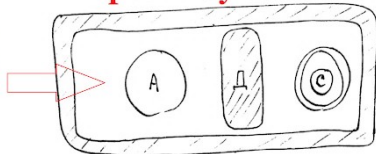
Записка Я.Б. Зельдовича и А.Д. Сахарова Ю.Б. Харитону «Об использовании изделия для целей обжатия сверхизделия РДС-6С»

Zeldovich & Sakharov
14 Jan 1954, Secret
14 января 1954 г.¹
Сов. секретно
(Особой важности)

Товарищу Харитону Ю.Б.

В настоящей записке сообщаются предварительная схема устройства для АО² сверхизделия и оценочные расчеты ее действия. Применение АО было предложено В.А. Давиденко.

Схема **Proposed by V.A. Davidenko**



Предлагаемая система состоит из металлического корпуса (...), разделенного диафрагмой Д на два приблизительно равных объема. Общий вес конструкции около 26–30 тонн.

(...)
В одном объеме находится изделие А¹, в другом — изделие С¹. Изделия А и С окружены борной заливкой (**Boron filling**)

Первый период — распространение энергии по изделию А — не рассматриваем; в этом периоде вначале энергия более чем наполовину представляет собой энергию излучения и распространяется по механизму лучистой теплопроводности, однако к концу периода уже вырабатывается ударная волна, скорость которой становится больше скорости диффузии излучения.

(...)
Исполнено от руки в 1 экз. на 16 листах
Исп. Зельдович Я.Б. и Сахаров А.Д.
Дело № 4. 14/1. А. Сахаров

Маш. 9/10 оп
14/1 54 г.

Архив ВНИИЭФ. Ф. 1. оп. 35, л. 7–92. Ручкопис Я.Б. Зельдовича и А.Д. Сахарова. Подлинник.

128

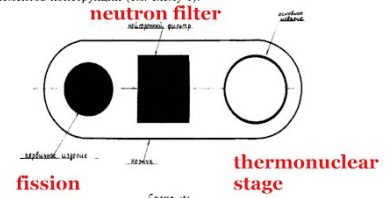
Отчет А.Д. Сахарова и Д.А. Франк-Каменицкого «Атомное обжатие»

A.D. Sakharov and D.A. Frank-Kamenetsky, "Atomic Compression", 9 Dec 1954, Secret

9 декабря 1954 г.¹
Сов. секретно
(Особая папка)
Экз. № 1

I. Принципы действия

Система атомной обжатия (сокращенно АО) состоит из следующих основных элементов конструкции (см. схему 1).



(...)
Применяя атомное обжатие, принципиально возможно сжать десятки и даже сотни кг легкого вещества внутри тяжелой оболочки до плотности, в десятки раз превосходящей его начальную плотность, что позволяет вызвать в легком веществе **термоядерный взрыв** с высоким коэффициентом использования.
(...)
Density compression factor of 10 is possible
Полнотелые конструктивные элементы
III. Ожидаемые характеристики системы

По предварительным оценкам принципиально возможно создание системы АО со следующими ориентировочными характеристиками. Общий вес около 15 тонн. **Mass of proposed bomb = 15 tons**

При сгорании легкого вещества на (...) % выделяется энергия, равная 7,5 мегатонн ТЭ. **Yield of proposed [15 ton] bomb = 7.5 Mt**

Создание технически совершенной системы АО в габарите, существенно меньшем 15 тонн, вероятно, является более сложной, но тоже выполнимой задачей.

Создание технически совершенной системы АО в габарите 15 тонн должен предшествовать опыт с более примитивной системой, проверяющий основные физические принципы АО и не требующий для своей подготовки длительной теоретической работы.

SOURCE:

Atomic project of the USSR: documents and materials: [in 3 volumes] / Ed. ed. L. D. Ryabeva. - 1998-2010.Т. 3. Hydrogen bomb, 1945-1956. Book. 2 / State. atom corporation. Energy "Rosatom"; comp.: G. A. Goncharov (responsible comp.), P. P. Maksimenko. - 2009.

В результате согласования требований, вытекающих из конструкции изделия и возможностей самолета-носителя, установлены допустимый вес и габарит всего изделия, а именно:

общий вес — до ~ 25 т,
диаметр — до (...) м.

По условиям испытания взрыв должен быть произведен при сбрасывании изделия с самолета. При взрыве столь значительной силы единственным способом сохранить самолет-носитель от действия теплового излучения является применение парашюта для изделия, сильно замедляющее его падение и позволяющее самолету за это время уйти на большое расстояние.

Необходимость применить парашют потребовала расхождения некоторой части из имеющихся весов и объемов, которые в противном случае могли быть использованы для повышения эффективности основной части изделия.

РДС-202 построено по принципу РДС-37 и отличается от него лишь значительными размерами, связанным с этим заметно лучшим использованием ядерного горючего и гораздо большей абсолютной мощностью.

(...)
Расчетное обследование ряда вариантов конструкции было проведено для веса Li^6D около (...) кг, и оно показало, что в лучшем из обследованных вариантов мощность заметно превосходит первоначально намеченное значение и достигает по расчету 38 млн т³. В связи с этим результатом количество Li^6D для РДС-202 может быть значительно уменьшено.

³ Фактическая мощность должна быть несколько выше, т.к. образующийся при взрыве U^{237} в действительности делится с большим сечением, чем принято в расчете.

481

(Note: the planned RDS202 test was postponed on 16 May 1957 after successful tests of products 245 and 205, but the basic concept of RDS202, being a very high yield bomb around 25 tons was resurrected later.)

As a result of the coordination of the requirements arising from the design of the product and the capabilities of the carrier aircraft, the permissible weight and size of the entire product are established, namely:

total weight - up to ~ 25 t,
diameter - up to (...) m.

According to the test conditions, the explosion must be produced when the product is dropped from the aircraft. With an explosion of such a significant force, the only way to save the carrier aircraft from the effects of thermal radiation is to use a parachute for the product, which greatly slows down its fall and allows the aircraft to go a long distance during this time.

The need to use a parachute required the expenditure of some of the available weights and volumes, which could otherwise be used to increase the efficiency of the main part of the product.

RDS-202 is built on the principle of RDS-37 and differs from it only in significant dimensions, associated with this noticeably better use of nuclear fuel and much greater absolute power.

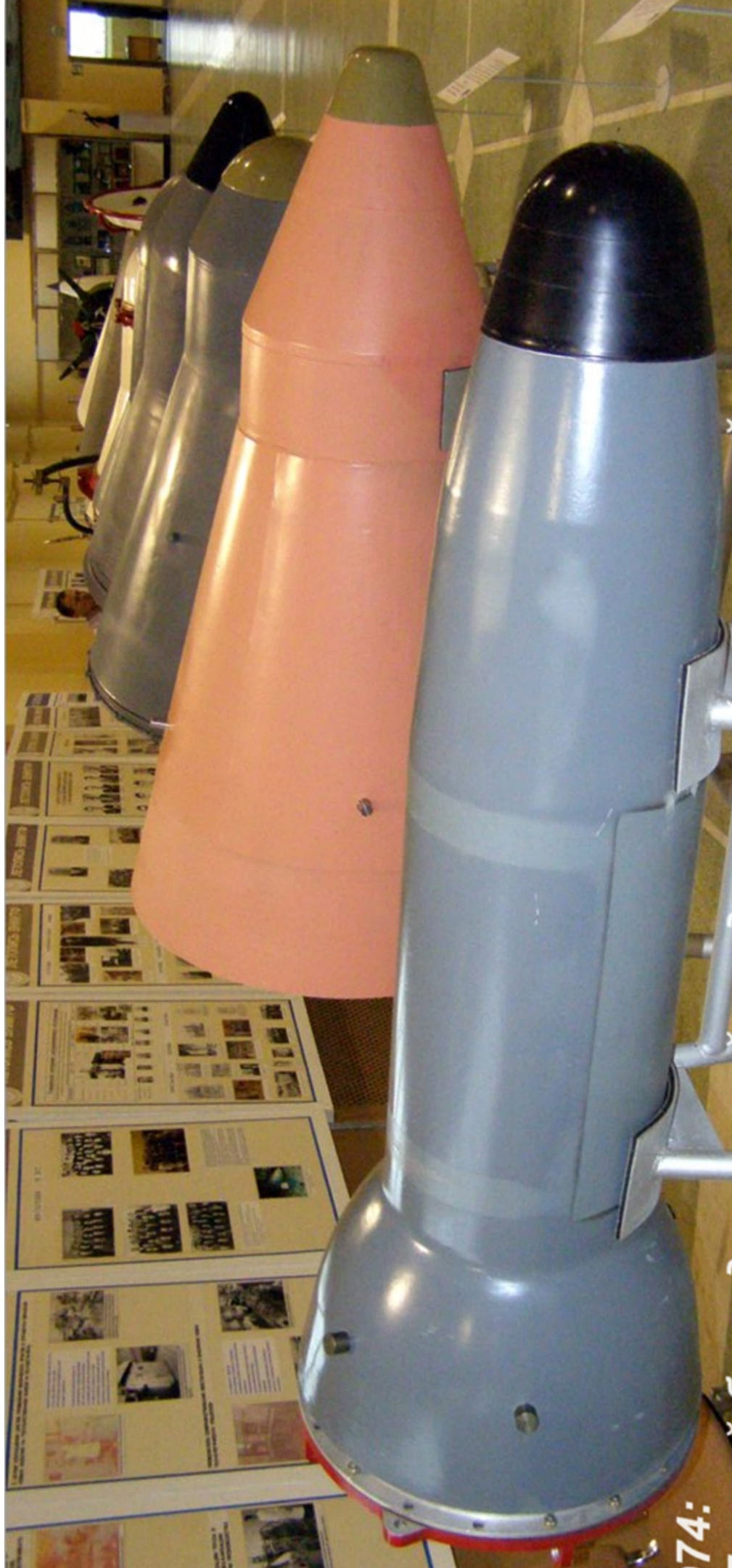
(...)
A design survey of a number of design variants was carried out for a weight of Li^6D of about (...) kg, and it showed that in the best of the surveyed variants, the power significantly exceeds the originally intended value and reaches 38 million t³ according to the calculation. Due to this result, the amount of Li^6D for RDS-202 can be significantly reduced.

³The actual power should be slightly higher, because the U^{237} formed during the explosion is actually divided with a larger cross-section than is assumed in the calculation.

481

1974:

"Боевой блок для первой разделяющейся головной части баллистической ракеты морского базирования. Среди разработчиков проект получил название "Сто на сто" (вместить в 100 кг заряда мощность в 100 килотонн), трех на одной ракете-носителе. Масса ББ 170 кг. Изделие принято на вооружение в 1974 г." - MIRV (3 warheads per SLBM), 1kt/kg = 170 kt from 170 kg mass



1953 Nevada 15 kiloton nuclear test Grable at 524 ft burst altitude, smoke-screen protection effects report:

Elmer H. Engquist and Charles W. Forsthoff, *Protection Afforded by Operational Smoke Screens Against Thermal Radiation*, Operation Upshot-Knothole, project 8.4-1, weapon test report WT-768, DTIC report ADA995215:

175 smoke pots 200-300 ft from ground zero established a 3.8 grams/m² smokescreen (white smoke screen can be seen to the right of ground zero in this photo). At a slant distance of 2238 feet from bomb (or 2166 ft from ground zero), the free-field (unshielded) thermal exposure was 57.5 +/- 5.0 cal/cm²; behind smoke-screen it was just 0.8 +/- 0.1. Hence, 98.6% +/-0.3% was stopped by the smoke screen.

Glasstone

Nuclear

be stopped
credible, then
editions. Liars

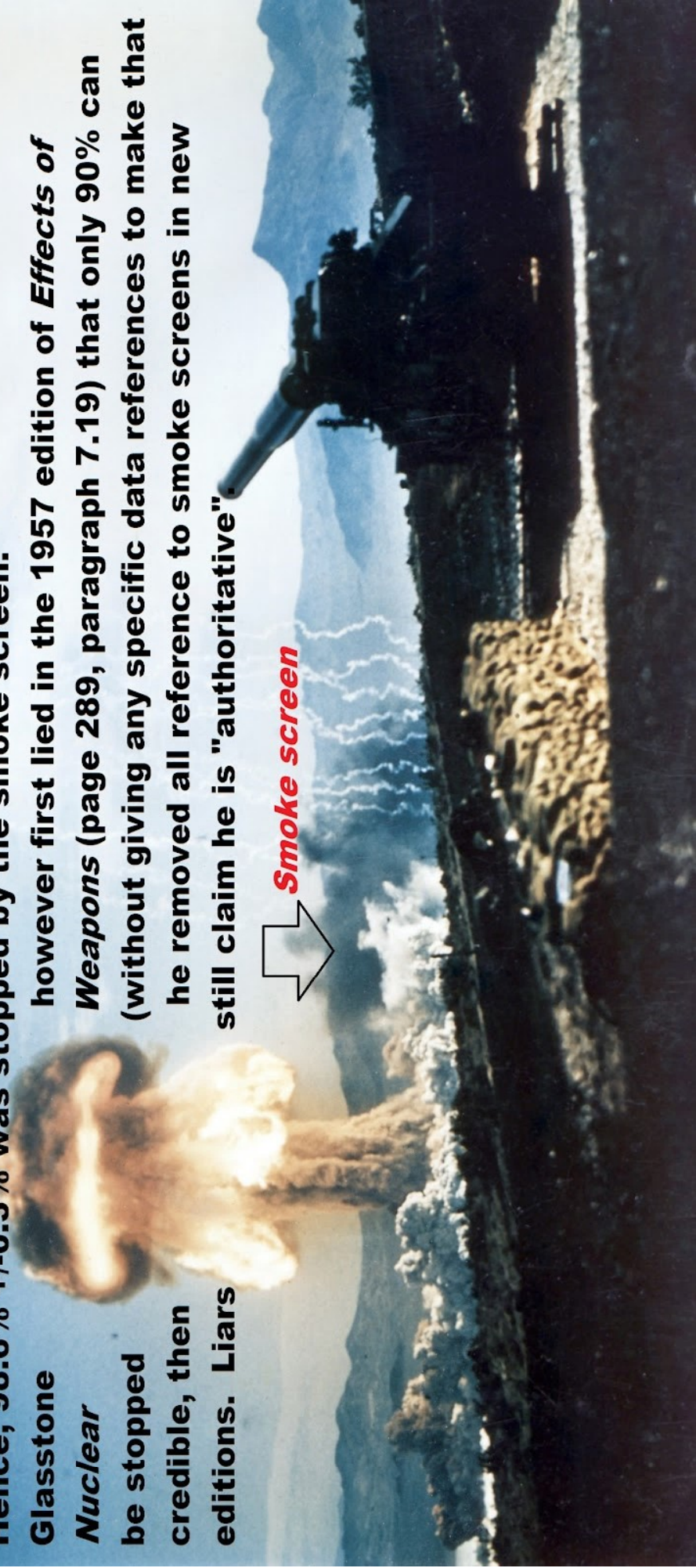
however first lied in the 1957 edition of *Effects of*

Weapons (page 289, paragraph 7.19) that only 90% can

(without giving any specific data references to make that
he removed all reference to smoke screens in new
still claim he is "authoritative".



Smoke screen



7
1284

~~SECRET~~
~~GUARD~~
CONFIDENTIAL

ROYAL MILITARY COLLEGE OF SCIENCE INFORMATION BUREAU	
R/59/197	1



DECLASSIFIED FOR PRO
BY AWE ALDERMASTON.

ES5/196

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

101

BBOOS

REPORT No. T 62/57

OPERATION BUFFALO

THE INFORMATION CONTAINED IN
THIS DOCUMENT IS CLASSIFIED
CONFIDENTIAL
AND NOT AS INDICATED WITHIN
RMCS Date 29.5.86

Air and Ground Shock Measurements Group

Group Leader - N. S. Thumpston

CONFIDENTIAL

~~SECRET~~

~~GUARD~~

AWRE 1956 Height of burst curves

Winifred E. Worsfold: "The Variation of Pressure on the Ground with Height of Burst, Series II. Part I: The Variation of Peak Pressure". AWRE Report No. 0-42/57

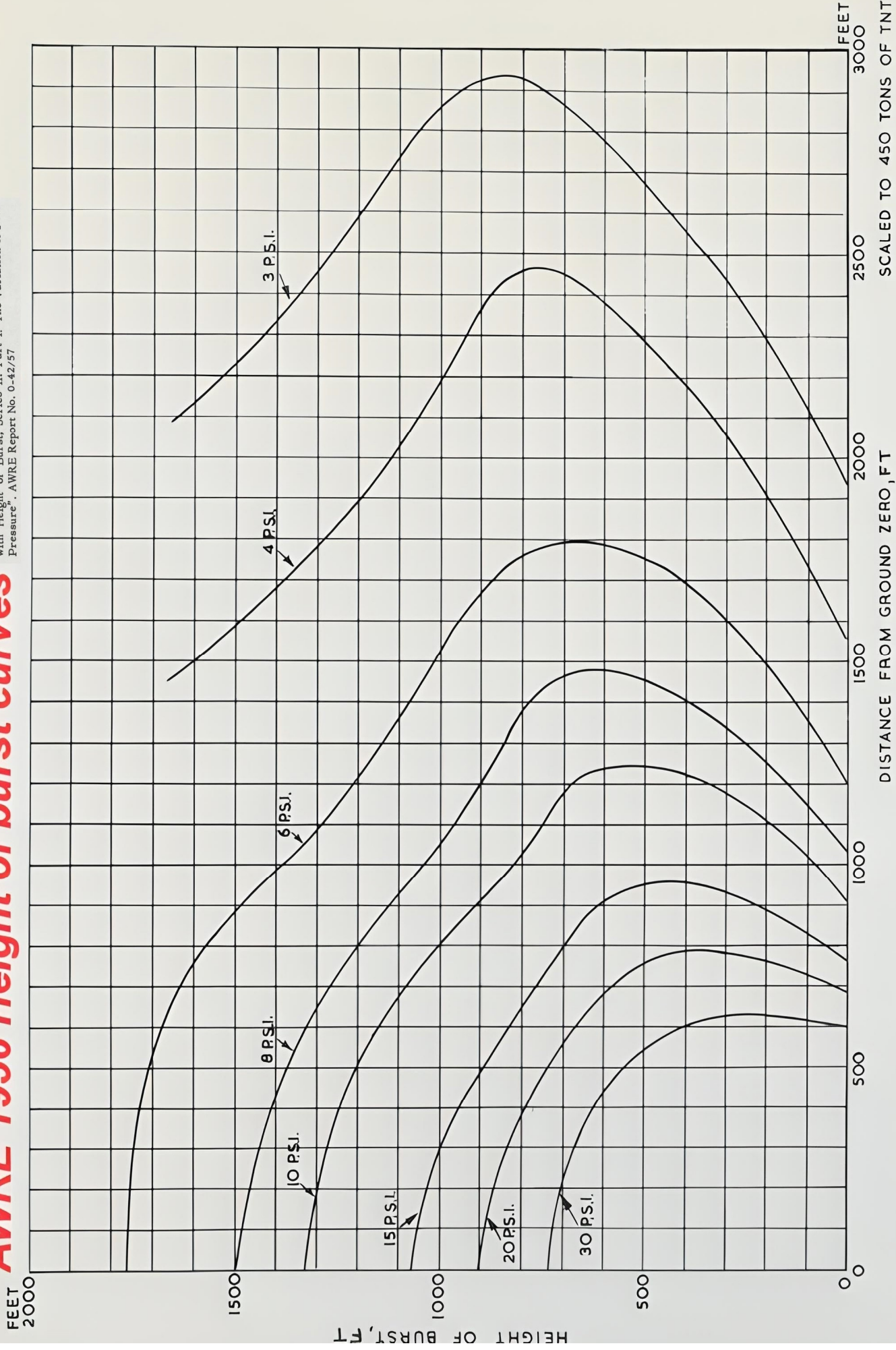


FIGURE 4I. HEIGHT OF BURST : PRESSURE / DISTANCE DATA FOR 450 TONS OF T.N.T.

AWRE T 62/57 used this 0.45 kt of TNT overpressure height of burst (0.45 kt was supposed to be the blast yield of 1 kt total yield nuclear bomb) to estimate yields of 17, 1, 2.5 and 15 kt for Buffalo shots (or "rounds") 1, 2, 3 and 4. There are issues with this, first blast yield is not always 45%, and TNT tests in the UK over concrete don't compare well to Maralinga.

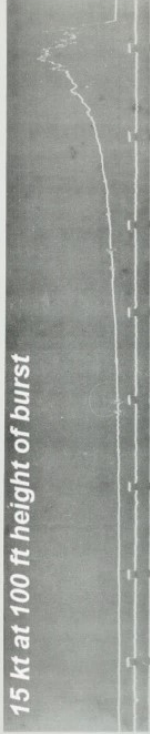


FIG. 5. **Buffalo-1 precursor** AG 104 1170 FT. 36 P.S.I.

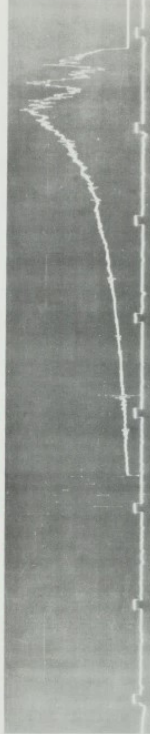


FIG. 7. **Buffalo-1 precursor** AG 108 1520 FT. 22.7 P.S.I.

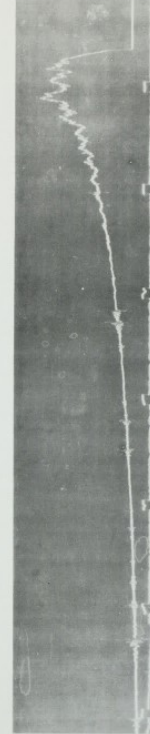


FIG. 8. **Buffalo-1 precursor** AG 109 1730 FT. 20.4 P.S.I.

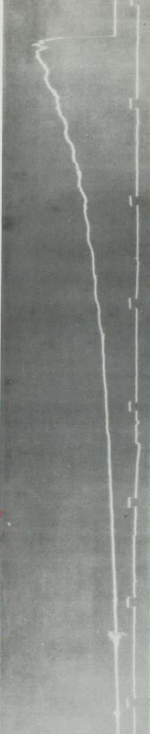


FIG. 9. **Buffalo-1 near ideal** AG 111 1960 FT. 15 P.S.I.

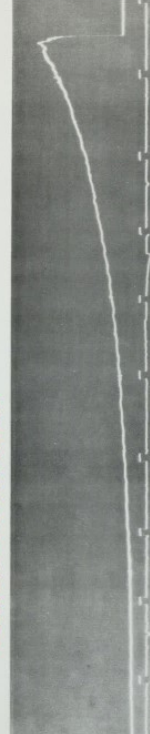


FIG. 10. **Buffalo-1 near ideal** AG 112 2140 FT. 13.5 P.S.I.
Buffalo-1 precursor waveform development and fading
Ambient air: 22C, 998mb, 18% humidity

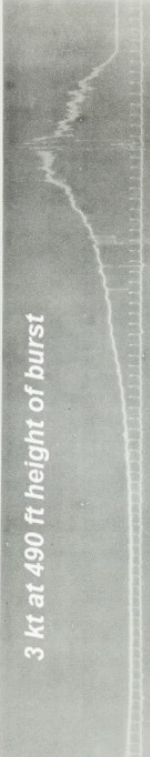


FIG. 21. **Buffalo-3 precursor** AG 405/1 740 FT. 24.7 P.S.I.



FIG. 22. **Buffalo-3 precursor** AG 407 990 FT. 16.4 P.S.I.



FIG. 23. **Buffalo-3 precursor** AG 408 1320 FT. 9.9 P.S.I.

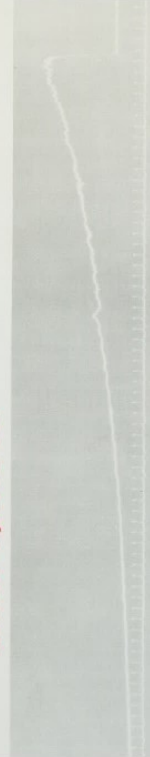


FIG. 24. **Buffalo-3 near ideal** AG 411 1750 FT. 8.9 P.S.I.

(Buffalo-3 ambient air: 24.1C, 998mb, 35% humidity)

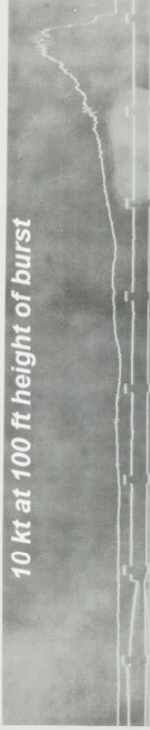


FIG. 11. **Buffalo-4 precursor** AG 304 1140 FT. 32 P.S.I.

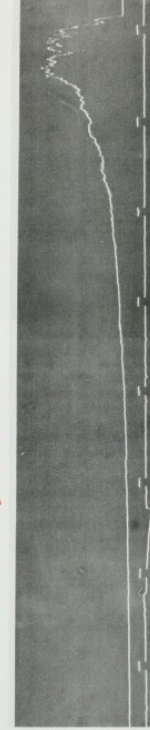


FIG. 12. **Buffalo-4 precursor** AG 306 1290 FT. 28 P.S.I.



FIG. 13. **Buffalo-4 precursor** AG 308 1480 FT. 24.4 P.S.I.

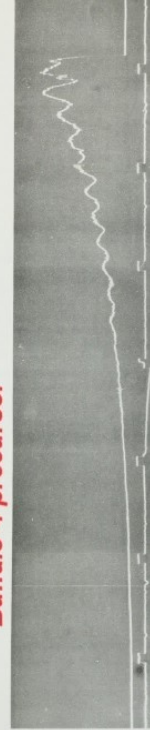


FIG. 14. **Buffalo-4 precursor** AG 310 1680 FT. 17.8 P.S.I.

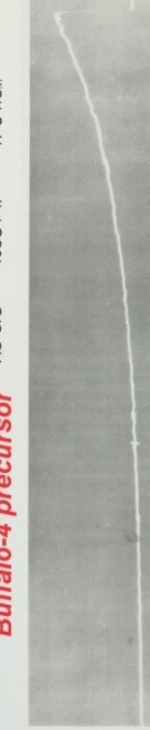


FIG. 15. **Buffalo-4 near ideal** AG 311 1920 FT. 14.2 P.S.I.
Buffalo-4 ambient air: 13.1C, 994mb, 84% humidity

1.5 kt Buffalo-2: Maralinga surface burst

X DIAPHRAGM GAUGES

⊙ TUBE RESULTS

AMBIENT AIR:
22.6C
35% HUMIDITY
992 mb

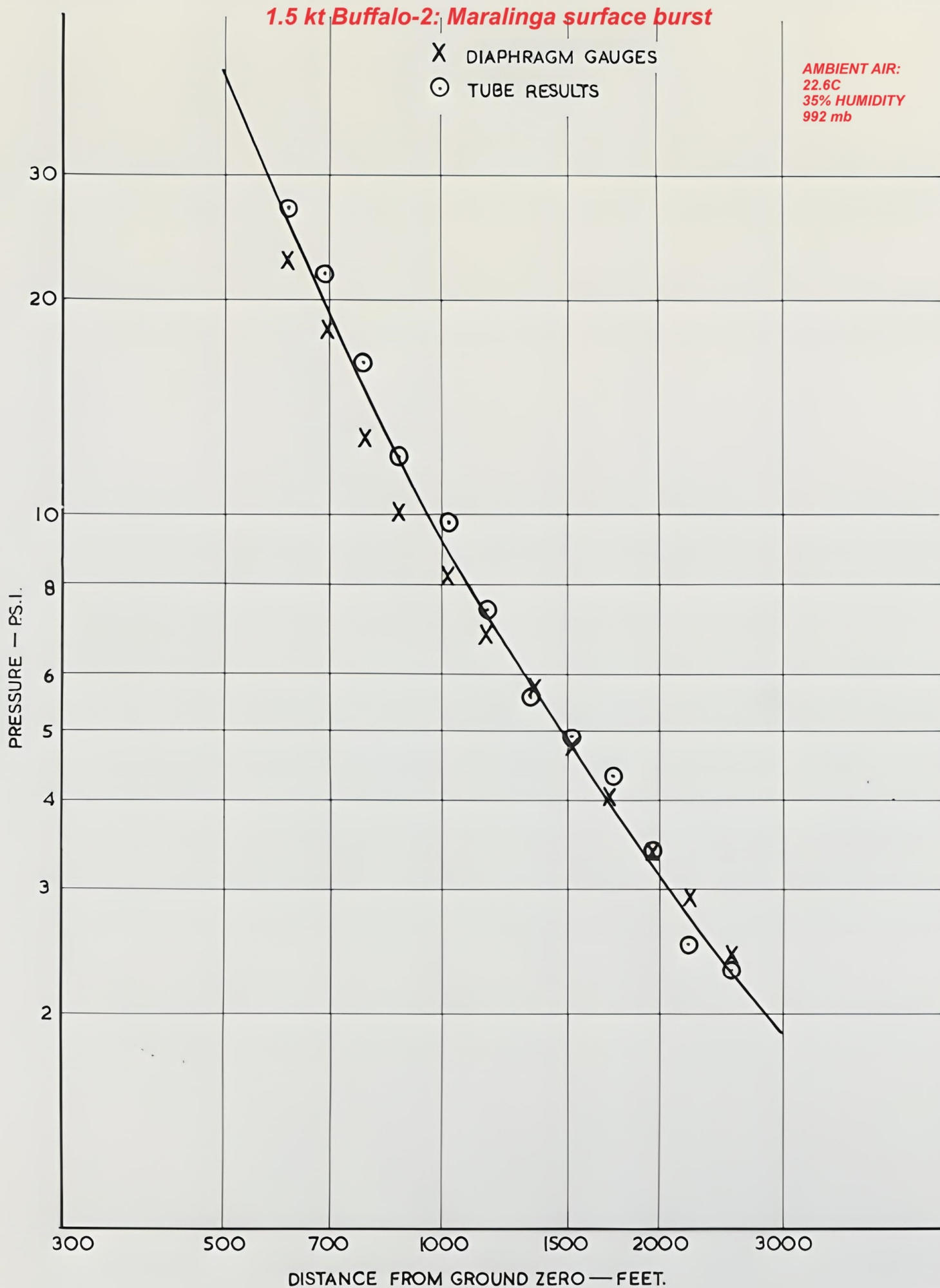
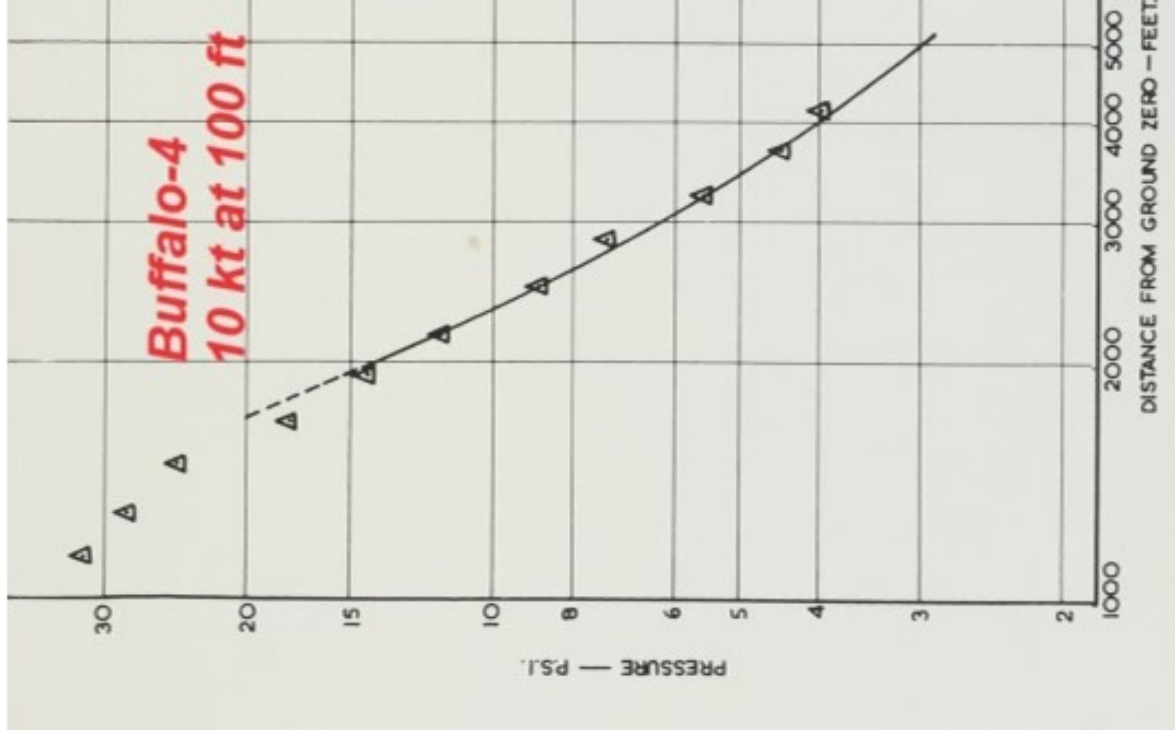
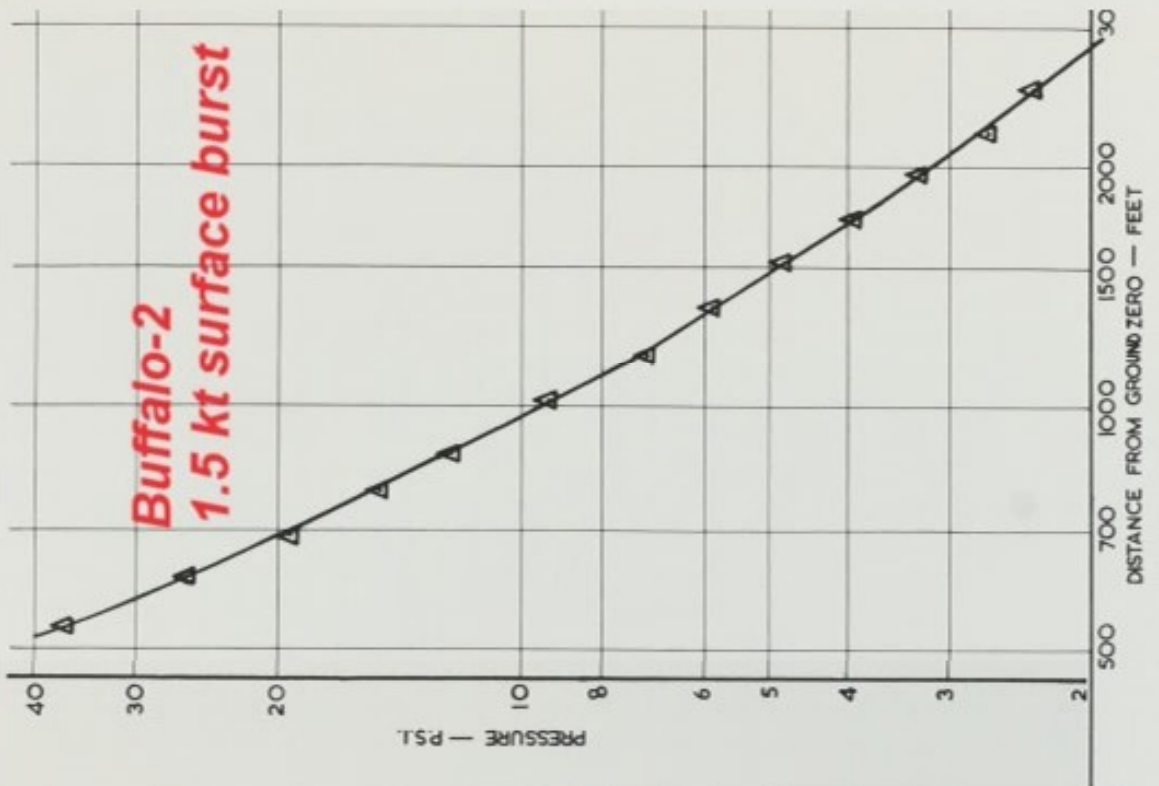
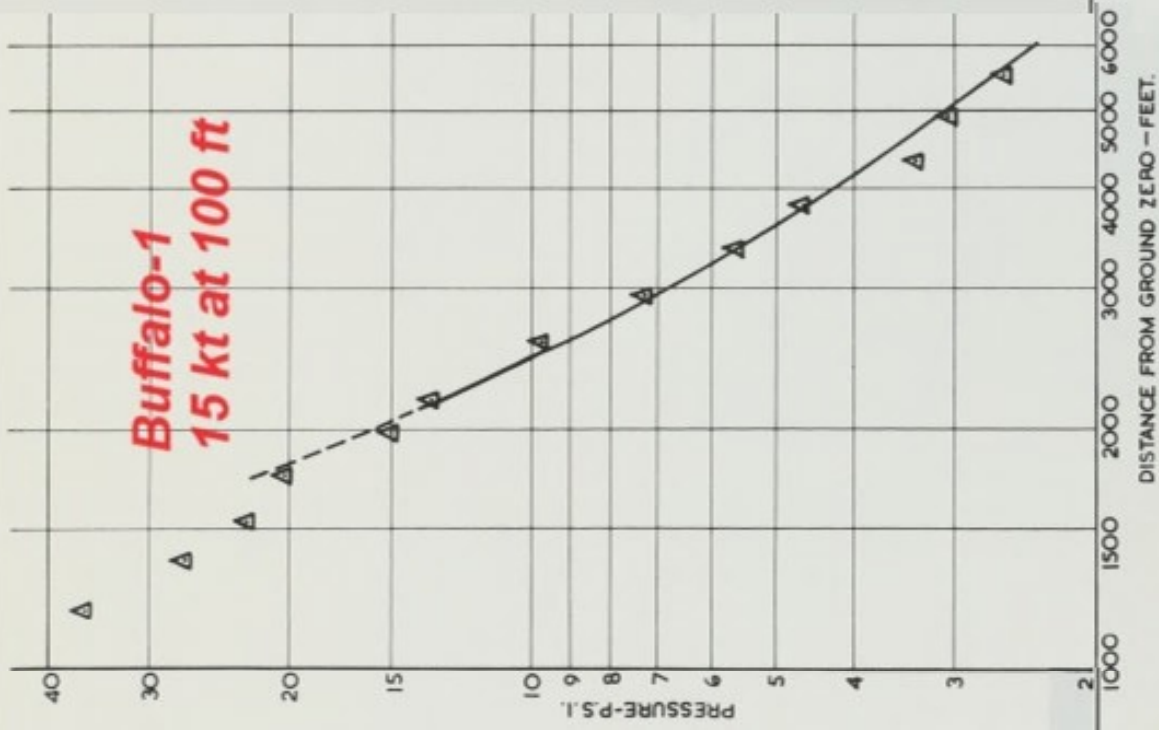


FIG. 30. ROUND 2. — PRESSURE / DISTANCE CURVE. DIAPHRAGM & TUBE RESULTS



ROUND.1. - PRESSURE /DISTANCE CURVE. F.M.T

ROUND 2. - PRESSURE /DISTANCE CURVE F.M.T RESULT

ROUND 4.- PRESSURE /DISTANCE CURVE F.M.T

RECORD

AWRE T 4/65

030

Copy No. 58

AWRE T 4/65

(CLEARED FOR CANADA AND AUSTRALIA)

UNCLASSIFIED



DEF E 16 / 185

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

AWRE REPORT No. T 4/65

B0153

OPERATION ANTLER

Air Shock Measurements

R. G. Turner

REF	<input checked="" type="checkbox"/>
INV.	<input type="checkbox"/>
AUTHOR	<input type="checkbox"/>
SUBJECT	<input type="checkbox"/>
A LIST	<input checked="" type="checkbox"/>
ABST.	<input checked="" type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

UNCLASSIFIED

A.W.R.E.,
Aldermaston, Berks.

(CLEARED FOR CANADA AND AUSTRALIA)

March 1965

[REDACTED]

Summary

On Operation Antler measurements were made of the shock overpressure/time relationship at sites down the main instrument lane, similar measurements at a few other isolated sites, and peak free air shock overpressure by a smoke rocket technique.

Three types of instrument were used. Two gave a pressure/time history of the shock wave at the recording site; the third, a measurement of the peak overpressure at the recording site.

The pressure/distance data for the precursor-free regions of the main instrument lanes have been compared with Foulness small charge data to give estimated total energy yields of:-

Round 1: 0.65 ± 0.05 kilotons **100 ft tower burst**

Round 2: 6.86 ± 0.36 kilotons **100 ft tower burst**

Round 3: 17.9 ± 0.9 kilotons. **1,000 ft balloon suspended air burst**

Time of arrival data, positive phase duration and positive phase impulse data are included. Canadian measurements of the free air shock using a smoke rocket trail technique are reported elsewhere.

NOTE: blast peak overpressure determined yields above have a source of error in the assumed conversion between blast yield and total nuclear yield (usually assumed to be 45% in UK reports, 50% in USA reports), because the surface portion of the blast wave is subject to thermal flash convective heating of the air near the ground surface even where a precursor does not occur, when this extra energy thus added from the thermal flash to the blast, boosts the effective blast yield, just as neutron heating of air around the fireball boosts blast.

UNCLASSIFIED

TABLE 2

AIR BLAST DATA - STANDARDISED VALUES

Operation ANTLER Round No. 1 (1013 mb, 15°C, still air) Date 14/9/57 Time of Firing 1435 hours IK

Height of Burst; 105 ft

Correction Factors (after Wind Correction)

Conditions of Burst; Tower

Distance $(\frac{P_0}{1013})^{1/2}$; 0.996.

Type of Terrain; Limestone strata overlain with fine red sand

Pressure $\frac{1013}{P_0}$; 1.012.

Site No.	Gauge Type	Ground Range, ft	Peak Overpressure, p.s.i.	Remarks
AG 205	Tubes	1272	5.0	Times of arrival for wind correction obtained from US Capabilities of Atomic Weapons 1955
AG 205	Tubes	1396	4.6	
AG 206	Tubes	1570	3.7	
AG 208	Tubes	1767	3.4	
AG 209	Tubes	2003	3.05	
AG 210	Tubes	2302	2.50	

UNCLASSIFIED

TABLE 3

AIR BLAST DATA - STANDARDISED VALUES

Operation ANTLER Round No. 2 (1013 mb, 15°C, still air) Date 25/9/57 Time of Firing 1000 hours IK
 Height of Burst; 106 ft Correction Factors (after Wind Correction)
 Conditions of Burst; Tower Distance $\left(\frac{P_0}{1013}\right)^{\frac{1}{3}}$; 0.997. Time $\left(\frac{P_0}{1013}\right)^{\frac{1}{3}} \left(\frac{273 + T}{288}\right)^{\frac{1}{3}}$; 0.995,
 Type of Terrain; Limestone strata overlain with fine red sand Pressure $\frac{1013}{P_0}$; 1.009. Impulse $(T \times P)$; 1.004.

Site No.	Gauge Type	Ground Range, ft	Time of Arrival of Main Shock, s	Positive Duration, s	Peak Over-pressure, p.s.i.	Positive Impulse, p.s.i. s	Remarks
AG 411	FMT	1645	0.643	0.395	12.3	1.66	
AG 412	FMT	1844	0.777	0.433	10.5	1.66	
AG 401	FMT	2044	-	-	8.35	-	No time trace
AG 402	FMT	2203	1.042	0.492	7.28	1.45	
AG 403	FMT	2452	1.231	-	6.29	-	Recorder running erratically
AG 404	FMT	2662	1.397	0.518	5.25	1.21	
AG 405	FMT	2941	1.613	0.571	4.74	1.05	
AG 406	FMT	3210	1.828	0.586	4.05	0.91	
AG 407	FMT	3629	2.173	0.585	3.49	0.85	
AG 408	FMT	4077	2.548	0.645	2.71	0.78	
North Base	FMT	20936	-	-	0.28	-	Recorder hand switched

UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED

TABLE 5

AIR BLAST DATA - STANDARDISED VALUES

Operation ANTLER Round No. 3 (1013 mb, 15°C, still air) Date 9/10/57 Time of Firing 1615 hours IK
 Height of Burst; 992 ft
 Conditions of Burst; Triple balloon supported
 Type of Terrain; Limestone strata overlain with fine red sand
 Correction Factors (after Wind Correction)
 Distance $\left(\frac{P_0}{1013}\right)^{\frac{1}{3}}$; 0.992. Time $\left(\frac{P_0}{1013}\right)^{\frac{1}{2}} \left(\frac{273 + T}{288}\right)$; 1.024.
 Pressure $\frac{1013}{P_0}$; 1.025. Impulse $(T \times P)$; 1.050.

Site No.	Gauge Type	Ground Range, ft	Time of Arrival, s		Positive Duration, s	Time to Second Shock, s	Peak Over-pressure, p.s.i.		Positive Impulse, S ₂ , p.s.i. s	Remarks
			Precursor	Main Shock			S ₁	S ₂		
AG 516	FMT	1353	0.435	-	0.545	0.904	30.1	5.88	6.09	
AG 517	FMT	1601	0.523	-	-	1.015	18.0	-	-	Gauge disconnected before end of positive phase
AG 512	FMT	1800	0.621	-	-	1.094	13.9	5.48	-	Gauge disconnected before end of positive phase
AG 513	FMT	2077	-	-	-	-	7.17	-	-	Fault occurred at time zero. No time trace
AG 514	FMT	2395	0.947	-	0.536*	1.481	8.50	0.221	2.42*	*Leaky gauge
AG 515	FMT	2693	1.157	-	0.743	1.676	9.99	0.219	3.12	
AG 501	FMT	2991	1.366	-	0.767	1.890	9.73	0.233	3.05	
AG 503	FMT	3835	-	2.013	0.709*	2.495	6.32	0.650	2.08*	*Leaky gauge
AG 504	FMT	4281	-	2.363	0.866	2.827	5.84	0.678	2.29	
AG 505	FMT	4827	-	2.785	0.943	3.240	4.73	0.548	2.11	
AG 506	FMT	5423	-	3.248	0.980	3.700	3.67	0.449	1.87	
AG 507	FMT	6068	-	3.782	1.06	4.212	3.23	0.369	1.65	
North Base	FMT	24798	-	-	-	-	0.54	-	-	Recorder hand switched
TR 517	FMT	1835	-	-	0.532	-	11.8	-	3.26	
TR 513	FMT	2265	-	-	0.701	-	12.0	-	3.75	

UNCLASSIFIED

UNCLASSIFIED

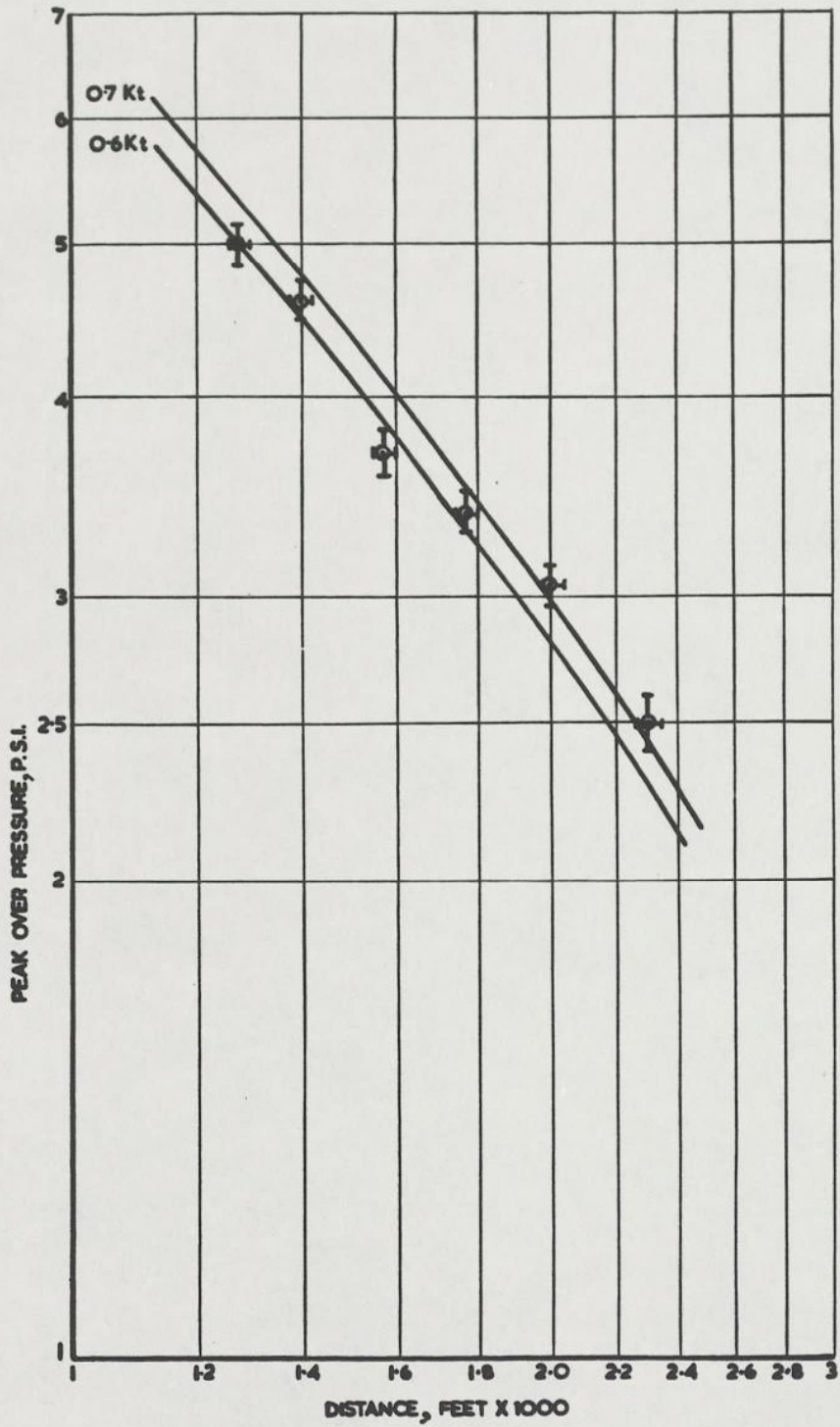


FIGURE 1. ROUND 1. PEAK OVER PRESSURE

UNCLASSIFIED

UNCLASSIFIED

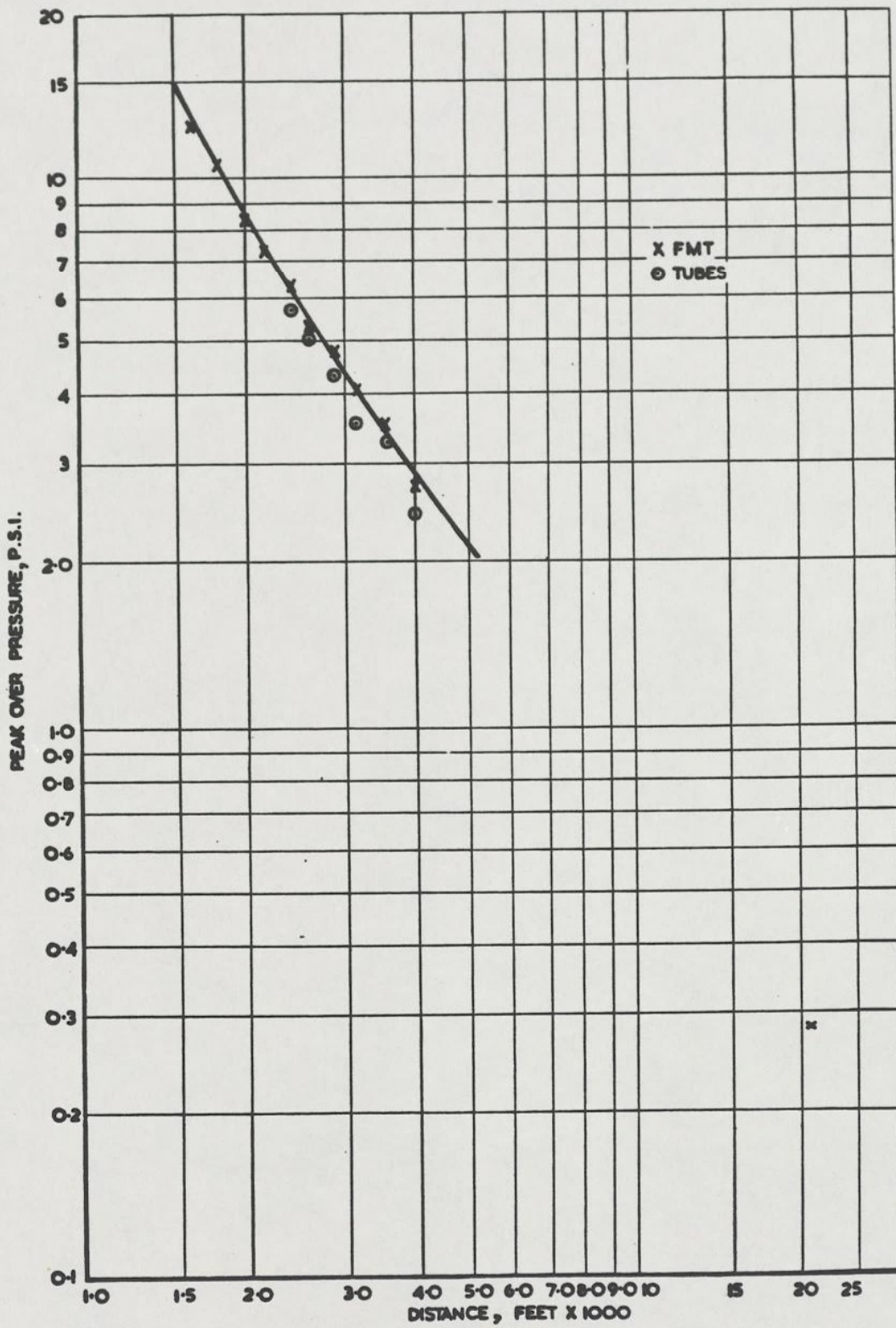


FIGURE 2. ROUND 2

UNCLASSIFIED

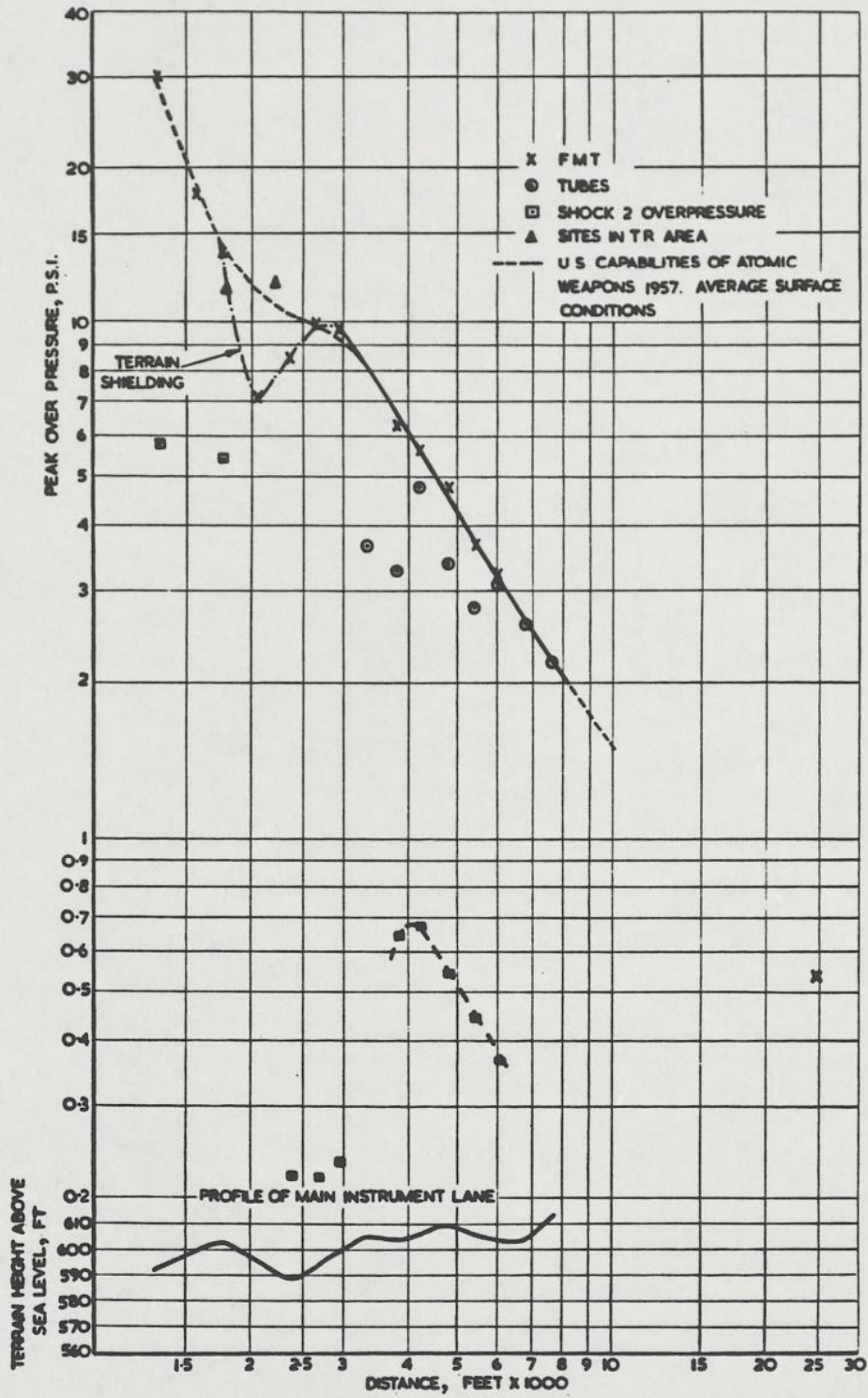
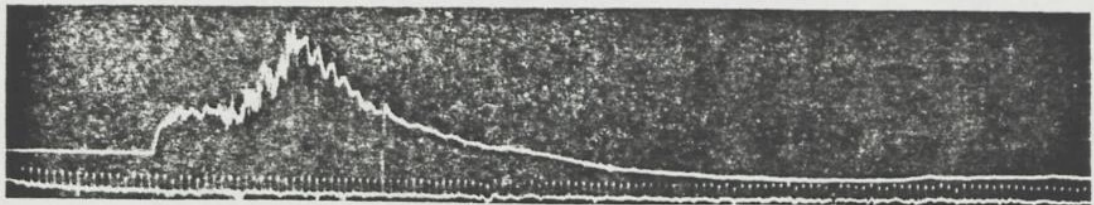


FIGURE 6. ROUND 3

UNCLASSIFIED

UNCLASSIFIED



AG 516

1353 FT

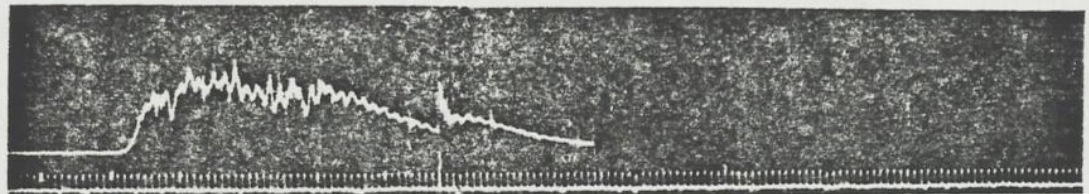
30.1 P.S.I.



AG 517

1601 FT

18.0 P.S.I.



AG 512

1800 FT

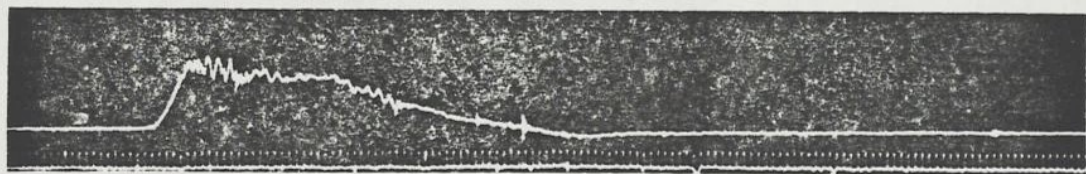
13.9 P.S.I.



AG 513

2077 FT

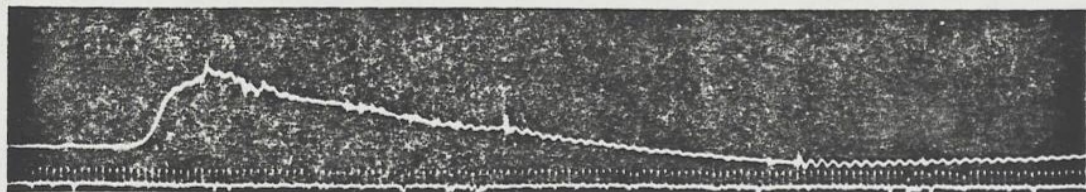
7.17 P.S.I.



AG 514

2395 FT

8.50 P.S.I.



AG 515

2693 FT

9.99 P.S.I.

FIGURE 12 ROUND 3

-27-

UNCLASSIFIED

UNCLASSIFIED

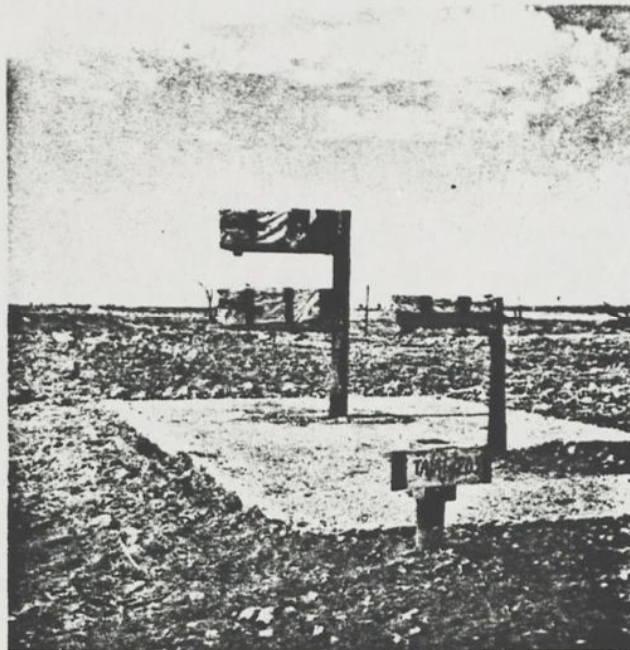


FIGURE 15. SITE AG 205 ROUND I. TYPICAL
INSTALLATION



FIGURE 16. SITE AG 513 ROUND 3. 2077 FT FROM GZ
LOOKING FORWARD TO THE RIDGE AT 1700 FT

-30-

UNCLASSIFIED

~~SECRET~~ U. EYES ONLY

~~SECRET~~

UK U/C
15/3/55 AD/Safety/2
Reference AB/633/58/CAA

0196

11/4/55
MINISTRY OF DEFENCE
SC (NUC) 2
LONDON SW1A

6056

Permanent Proving Ground Trials
0171 JC

Admiral P.W. Brooking

Co 60 pellets found at Maralinga

U/C w/ Def Nuc
Tech info 23/1/55

Downgraded to
UNCLASSIFIED

DEFB 16/443

Halliday rang me this morning to say that Myers has been enquiring about the Co60 pellets found at Maralinga by Turner. I have tried, without success, to ring Myers to find his source of information and the reason why he is pursuing the matter. The facts are as follows:-

Co60 was used at Antler as a detector. With some difficulty I obtained permission from the Director to inform Titterton (as Chairman of the Safety Committee) that we intended to use such an indicator. Titterton was entirely sympathetic, raised no difficulties, realised that we were not adding any real hazard, and agreed that the information should go no further on the Australian side. Recently Turner, the Australian who is responsible for Health Physics at Maralinga in the inter-trial period, claims to have found Co60 in some pellets which he has collected and which we have arranged should be sent back to U.K. As soon as I heard of this I wrote to Titterton stating what the position was and suggesting that it would be as well if information on this subject were not extended any further in Australia. I have not as yet had any reply from him.

I shall not have an opportunity to get in contact with Myers today. Tomorrow evening I leave for Risley and expect to be in again on Friday. You may think it worthwhile to get in touch with Myers. The fact that he is asking questions on the subject suggests that the information has already received a wider circulation than I thought it would.

/Since

12th August, 1958

EGIMITE
& CMLtd.
52-2165
ode 18-76

~~SECRET~~

SECRET

SECRET U.K. EYES ONLY

Reference AG/633/58/CAA

Since dictating the above I have had a call from Frankie Lloyd who raised the matter of Co60 amongst other things. It appears that Turner has reported to Dick Durance in addition to reporting here. In doing so I think Turner has misconstrued his terms of reference which were to report in the first instance to A.W.R.E. The correspondence will be sent down here by Frankie. I hope that I shall shortly have a reply from Titterton but at present I do not know how to get in touch with him. I have asked Mrs. Prosser to find from Australia House where Titterton can be contacted. If it is necessary to correspond with the Australian Department of Supply or the Range Commander, I should much prefer to do so in terms agreed with Titterton, rather than to write indepdently.

P.A.A.

C. A. Adams
C.T.

EGIMITE
& CMLtd.
52-2165
ode 18-76

SECRET